# WORK PLAN

# BUFFALO RIVER WATERSHED

Amherst County, Virginia

Prepared Under the Authority of the
Watershed Protection and Flood Prevention
Act (Public Law 566, 83d Congress, 68
Stat. 666) as amended.

21462

# ADDENDUM

## BUFFALO RIVER WATERSHED WORK PLAN, VIRGINIA

This addendum shows the project costs, benefits, and benefit-cost ratio based on 6 7/8 percent interest rate, current normalized prices, and 1973 construction costs. Annual project costs, benefits, and the benefit-cost ratio are as follows:

| | | |
|---|---|---|
| 1. | Project costs are | $173,219 |
| 2. | Project benefits are | $248,365 |
| 3. | The project benefit-cost ratio is | 1.4:1.0 |

The alternative selected for implementation as contained in this work plan, is based on a careful and deliberate consideration of the environmental and economic impacts of the project. There are no known unresolved environmental issues. The final environmental statement has been prepared to respond to the comments received on the draft environmental statement.

December 1973

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Amherst County, Virginia

Prepared Under the Authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress, 68 Stat. 666), as amended.

Prepared by: Robert E. Lee Soil and Water Conservation District

Amherst County Board of Supervisors



With assistance by:

U. S. Department of Agriculture, Soil Conservation Service

U. S. Department of Agriculture, Forest Service
in cooperation with the Virginia Division of Forestry

Virginia Soil and Water Conservation Commission

April 1972

## ACKNOWLEDGEMENTS

The agencies listed below provided reports or other assistance during the development of this watershed work plan.

U. S. Forest Service
Virginia Division of Forestry
Virginia Soil and Water Conservation Commission
U. S. Agricultural Stabilization and Conservation Service
Cooperative Extension Service
U. S. Fish and Wildlife Service
Virginia Department of Highways
Virginia Division of State Planning and Community Affairs
U. S. Geological Survey
U. S. Weather Bureau
Virginia Commission of Game and Inland Fisheries
Virginia Division of Water Resources

Many other public and private agencies and individuals rendered very valuable services in the preparation of this plan. Their contributions are gratefully acknowledged.

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April 1972

## SUMMARY OF PLAN

As set forth in this work plan, Buffalo River drains approximately 60,500 acres in Amherst County, Virginia. This watershed work plan was prepared by the Robert E. Lee Soil and Water Conservation District and the Amherst County Board of Supervisors, the sponsoring local organizations.

Its headwaters originate in the steep foothills of the eastern slopes of the Blue Ridge mountains in northwestern Amherst County. The stream flows generally in a southeasterly direction, with the downstream limit of this watershed project area about a mile southeast of U. S. Highway 29 at the Southern Railroad. Buffalo River is a tributary of the James River Basin. Six thousand five hundred sixty acres of the George Washington National Forest, administered by the U. S. Forest Service, are located in the watershed. The remaining 53,940 acres are currently in private ownership.

Most of this watershed land is in farm ownership. Currently about 600 of the 793 acres of flood plain lands are used for crops and pasture. Due to the flood hazard large areas are now used for pasture with limited management practices. When not subject to flooding these soils respond well to improved management, produce high yields and are easily developed for nonagricultural uses. Other problems in this watershed include damage to highways and transportation systems, water systems and other public utilities, erosion of uplands, sedimentation of the bottomlands and downstream channel areas. Economic growth and development of the area is being retarded due to lack of an adequate supply of municipal water. Annual floodwater damages including downstream sedimentation originating in this watershed are estimated at $121,040.

Problems in this watershed will be alleviated through the application of an overall watershed management plan. Average annual damages, including downstream sedimentation, will be reduced about 90 percent by the acceleration of land treatment and structural measures proposed in this plan.

Two floodwater retarding structures and two multiple purpose structures for storage of floodwater and sediment, along with municipal and industrial water for Amherst County will control the runoff from about 46.5 percent of the watershed. Dam 1B will provide 2,000 acre-feet and Dam 4 will provide 2,049 acre-feet of municipal and industrial water storage.

The area flooded by the 100-year frequency event will be reduced by an estimated 311 acres within the project area. Flooding by the two-year frequency storm will be limited to the lower elevations of the downstream reaches near U. S. 29 and the Southern railroad. Remaining annual floodwater damages originating within the watershed project area are estimated at $49,265 with the project installed. The average annual benefits from all planned structural measures are estimated to be $223,955. (See Table 6). The average annual cost is estimated to be $121,656, resulting in a benefit-cost ratio of 1.8 to 1.0 for all structural measures.

It is anticipated that the project can be installed in 6 years at a total cost of $2,556,035, of which Public Law 566 funds will provide $1,494,510 and others $1,061,525. Land treatment measures are estimated to cost $406,585 with Public Law 566 funds providing $154,200 for accelerated technical assistance and soil surveys, and other funds $252,385 for installation costs. In recent years the landowners and operators have installed land treatment measures amounting to $346,320 in addition to the measures proposed in this plan. Structural measures are estimated to cost $2,149,450, with Public Law 566 funds bearing $1,340,310 and others $809,140. Of the amount supplied from other funds, $461,786 represents land rights costs, $6,384 for relocation payments and $306,515 to provide for engineering services and construction necessary to include 4,049 acre-feet of municipal water storage in sites 1B and 4, with the remainder for project administration costs incurred by the sponsors.

The Robert E. Lee Soil and Water Conservation District will coordinate the installation of this project and will execute agreements with landowners or operators for installation of land treatment measures on private land. Land treatment measures for private land will be installed by owners and operators with such cost sharing assistance as is available through REAP at the time of installation. The Soil Conservation Service and Virginia Division of Forestry, through cooperative programs with the U. S. Forest Service, will provide technical assistance. Land treatment measures for federal land will be installed by the U. S. Forest Service, contingent upon approval of a request for supplemental funds to augment their going program funds.

Amherst County will secure the necessary land and water rights, and provide the non-federal share of the installation costs for structural measures as set forth in the watershed work plan agreement. In securing land rights, the County will meet the requirements of the Uniform Relocation and Real Property Acquisition Policies Act of 1970. The County will secure the engineering services for sites 1B and 4 by means of a negotiated A&E contract with a consultant firm acceptable to the Service. In connection with project administration, the County will administer construction contracts, provide

inspection services required for the water supply features and those they deem necessary for flood prevention features of the project, provide relocation assistance advisory services as may be needed in connection with the relocation of displaced persons, provide the clerical and administrative services that they require and bear the costs they incur. The County, at a later date, may request the Service to administer construction contracts. In addition, the County will at their expense provide access roads, parking, sanitary, safety and recreation facilities at the structure sites to enable fishing and general recreational use.

Amherst County will meet its financial responsibilities described in this work plan from locally available funds designated for this purpose.

The Service will provide engineering services required for sites 2 and 3 and provide the federal share of the installation costs as set forth in the work plan agreement. In connection with project administration, the Service will review the work performed by the A&E contractor, administer construction contracts if requested to do so by the sponsors, provide inspection services deemed necessary on all items of construction on which P. L. 566 funds are spent and any other items of construction which may affect the function or stability of the structures, assist the sponsors in gathering data to assure that proper relocation advisory assistance services are provided all displaced persons, provide the clerical, administrative and related services the above items require and bear the costs incurred.

Operation and maintenance of all structural measures will be performed by Amherst County at an estimated cost of $5,500 annually. Land treatment measures in the George Washington National Forest will be maintained by the U. S. Forest Service. Land treatment measures on non-Federal land will be maintained by the landowners and operators through agreements with the Robert E. Lee Soil and Water Conservation District.

## DESCRIPTION OF THE WATERSHED

Buffalo River watershed as set forth in this work plan all in Amherst County, Virginia, drains about 60,500 acres. Part of the Town of Amherst, county seat of Amherst County, is located in the downstream area of the watershed. Lynchburg, about 20 miles to the south, is the nearest large urban center. Roanoke, Richmond and Danville, Virginia are within 100 miles. Other metropolitan centers within 200 miles include Norfolk and Bristol, Virginia; Raleigh, Durham, Greensboro, Winston-Salem and Charlotte, North Carolina; Charleston and Huntington, West Virginia; Washington, D. C. and Baltimore, Maryland. These centers are easily accessible and provide markets and distribution centers for agricultural and manufactured products produced in the watershed.

The headwaters of Buffalo River originate in the steep ridges of the eastern slope of the Blue Ridge Mountains in central Virginia. The watershed is an irregular trapezoidal shape about 22 miles long, ranging from about 5 miles wide in the headwaters to about 11 miles in the downstream area. It is a tributary of the James River Basin.

There are three major upland soil associations of importance in the Buffalo River watershed.

The Porters, Brandywine and stony land association is found in the extreme northern part and represents about 20 percent of the watershed. This is a mountainous area of moderately deep to shallow soils. They have been developed mostly from granites, gneisses, schists, diorites and some greenstone, and are mostly in woodland.

The Porters, Hayesville association comprises about 30 percent of the western and north central area and currently is mostly in woodland. These are moderately shallow to deep well drained soils. Located on mountain and foothill slopes, with moderate natural fertility, they respond well to fertilization and improved management practices.

The Rabun, Wilkes, Hayesville, Dyke soil association covers the largest part of the watershed and represents nearly half of the area. These are reddish brown to brown loam soils. Rabun and Wilkes soils have formed from the weathering of hornblendes, diorites, granites gneisses and schists and Hayesville from granites, gneisses and schists. Dyke is a transported soil that developed mainly from greenstone. These are moderately fertile upland soils which respond well to improved management.

There are an estimated 793 acres of flood plain land below proposed structural measures, about 600 acres of which is currently used for cropland and pasture. These are the most fertile soils in the watershed. Even though they represent a relatively small portion of the total watershed, they are highly important to each landowner. Quite often they represent all, or most, of the tillable land and are used for cultivated crops in spite of the flood hazard. About 80 percent of the flood plain soils are the well drained Congaree and State. Chewacla and Wehadkee make up the remaining 20 percent and are somewhat poorly drained.

The area drained by the Buffalo River watershed is underlain by igneous and metamorphic rocks of Precambrian age. 1/ The upper 90 percent is underlain by the Blue Ridge complex which includes granites, gneisses, anorthosite, syenite, granodiorite, diorite, and monzonite. The formations present which are included in the Blue Ridge complex are the Pedlar, Marshall and Roseland anorthosite. The lower 10 percent is included in the Lynchburg formation which are metamorphosed sediments such as phyllite, graywacke and conglomerate.

1/ Geologic Map of Virginia, DMR 1963.

The Blue Ridge 1/ complex formations are jumbled and in many places it is difficult to tell which formation is actually present particularly in the Pedlar, Marshall and the Reusens migmatite which probably is also present.

Many of the outcrops are deeply weathered and a deep mantle of residuum is present except along the streams where hard bedrock is found in many places.

Some quarrying for use in roadbed material has been done in the watershed but no other economic mineral resources appear to be present.

The topography of the watershed varies widely from very steep in the headwaters ridges to moderately steep in the downstream portion. Elevations range from about 4100 feet above sea level along the ridge tops in the headwaters to 504 feet in the stream at the downstream end of the watershed.

Land cover conditions in the Buffalo River watershed vary from poor to very good, and have improved in recent years due to emphasis on livestock operations. Some areas remain which are in need of special attention for conservation measures. Approximately 74 percent of the watershed is in woodland, 2 percent in urban and built up areas in and around the Town of Amherst with the remaining 24 percent open agricultural areas. About 6,560 acres of the George Washington National Forest, managed by the U. S. Forest Service, is located in Buffalo River watershed. The remainder of the land is in private ownership.

Stream flow direction in the upper reaches is south to southwest, turning to an east to southeast direction near the confluence of the North Fork and South Fork. Stream gradients vary widely. In the steep headwaters, gradients in excess of 200 feet per mile are not uncommon. In the central area gradients average about 20 feet per mile, and range down to about 15 feet per mile in the downstream reaches.

Many tributaries varying in drainage area from less than one-half a square mile to over 10 square miles make up the drainage pattern. The main stem of Buffalo River begins at the confluence of the north and south forks near the community known as Forks of Buffalo. Other streams which account for a major portion of the drainage are Franklin Creek, Thrashers Creek, Stonehouse Creek, Mill Creek and Muddy Branch which enter the main stem from a northerly direction. Puppy Creek, Beaver Creek, Long Branch, Huff Creek and Tribulation Creek are the major tributaries on the southern side of the main stem.

1/ Geology and Mineral Resources of the Lynchburg Quadrangle Virginia, Bul. 74, VDMR, Brown, W. R., 1958.

The town of Amherst water system intake is located on the main stem of Buffalo River about 1.5 miles northeast of the junction of U. S. highways 60 and 29. The treatment plant has a capacity of 500,000 gallons per day. Finished water storage in the distribution system is 75,000 gallons, with average daily useage of about 280,000 gallons. This stream has been given a IIIA classification by the Virginia State Water Control Board, with special standards listed as suitable for public water supply in the water quality standards published by this Board June 1970. Average hardness of the water is 2 grains per gallon. There are no commercial, industrial or urban pollutants discharged into the stream above this location. This system supplies water to residents of the town of Amherst. The remainder of the residents are supplied water from wells or springs developed by the various landowners.

Annual precipitation averages about 45 inches. About 27 inches of this precipitation normally occurs as rain between the first of April and last of September, with the remaining 18 inches occurring as rain or snow between the first of October and last of March. Floods have been recorded in all months. Some of the more troublesome flood problems are caused by storms of tropical origin which frequently pass through the area in summer and fall causing widespread flooding and serious damage. The most recent of this type storm was the remanents of Hurricane Camille in August 1969 which produced up to 27 inches of rainfall and flood stages far in excess of those expected from a storm with a recurrence interval of 100 years.

Temperatures in this area average about 38 degrees fahrenheit in winter and 76 in summer. Winter time low temperatures below zero sometimes occur as over-night lows for a few days at the time. During occasional hot spells in summer temperatures sometimes reach 100 degrees or more for a few days. The lowest official temperature recorded in this area is 16 degrees below zero, and the highest 105 degrees above zero. The average growing season is about 190 days from mid-April to late October.

## Economic Data

Sale of dairy and livestock products account for most of the agricultural income in this watershed. Agriculture is an important segment of the county's economy; even though more people are employed in manufacturing and other off-farm work than are engaged in farming.

About 4,840 acres in the watershed are estimated to be in cultivated crops and orchards, 44,770 acres in woodland, 9,680 acres in pasture and 1,210 acres in miscellaneous uses. Flood plain land use below proposed structure sites consists of an estimated 100 acres of cultivated crops, 199 acres of hay, 303 acres of pasture

and 191 acres in other uses, mostly woodland and idle. Production levels with the existing flood hazard are about 18 tons of silage, 80 bushels of corn grain, 2.5 tons of hay and 110 animal grazing days of pasture.

Public lands in this watershed consist of 6,560 acres in the George Washington National Forest managed by the U. S. Forest Service and areas needed for highway rights-of-way. The remaining 53,940 acres is in private ownership.

The 315 farms in the watershed average about 200 acres in size. An estimated 3,500 people live in the Buffalo River watershed. Of these about 1,100 are rural non-farm residents living on small tracts along the primary and secondary road systems. The farm population is estimated at 900. About 1,500 people are urban residents living in and around the town of Amherst.

Currently land values, exclusive of buildings, range from $50 to $3,000 per acre depending on its location, accessibility, availability of utilities and development costs. Flood plain land values are estimated at about $300 to $500 per acre for agricultural use and up to $2,000 per acre for commercial or industrial use as part of tracts with useable upland. Where the flood plains are protected sufficiently for development for non-agricultural uses it is estimated that their value, exclusive of buildings, would increase to about $3,000 per acre if easily accessible, and about $2,000 per acre where they are not adjacent to existing roads.

The entire watershed is easily accessible from a network of public, private and national forest roads. U. S. Highways 60 and 29 intersect at Amherst. These are major national arterial highways providing access to all parts of the Nation. Motor freight service is available from about eight motor carriers at Amherst. Most of these companies provide interstate and intrastate service. Lynchburg, about 20 miles away, has 15 truck terminals. The mainline of the Southern Railway, which operates between Washington, D. C. and Birmingham, Alabama passes through Amherst. It is one of the major railroads of the nation and provides railway connections to all parts of the country. Eastern Greyhound Lines and Continental Trailways serve the area with frequent daily bus schedules. Interconnections with other lines provide adequate bus service to all parts of the nation. There are no licensed airports in Amherst County. Preston Glenn Field, Lynchburg's municipal airport, is about 25 miles from Amherst. This field is attended 24 hours a day with 16 regular scheduled flights providing service to other Virginia cities and Washington, D. C. Runway lighting, beacon, fuel, repairs and charter service along with ground transportation, food and lodging are available.

In general, the economy of Buffalo River watershed is fair to good. Development of this project will help promote an orderly development of the natural resources of the area and provide the residents with an opportunity for improved living conditions. Over 90 percent of the farms had gross sales of less than $5,000 in 1960. Size of farms in the watershed vary from less than 30 acres for some of the part-time operations to 732 acres for the largest operation in one ownership. Most of the commercial farms are one-family, owner-operated units, with day labor hired as needed to help harvest crops. A few of the larger operations employ both day labor and full-time employees who live on the farm and are paid a monthly salary. In recent years over half of the rural farm population has found it necessary to supplement their income with off-farm employment. This trend is expected to continue as the Lynchburg area grows. Population projections indicate that the population of the watershed will increase to between 9,500 and 11,500 by 1980 and to about 20,000 by the year 2000.

Electricity and telephone service are provided to all parts of the watershed. The Town of Amherst owns its water system which supplies the area inside the town corporate limits. Their treatment plant has a capacity of 500,000 gallons a day. Water useage by the 1,500 presently being served by the system is averaging about 280,000 gallons daily. Studies indicate that a constant demand in excess of 300,000 gallons a day must be provided through surface storage. The town also operates two sewerage treatment plants which provide primary treatment and continuous chlorination to serve a population of about 1600. Plans have been developed to supply natural gas to the Amherst area. These and other public utility plans are continually reviewed and facilities added, as needed, to provide for increased demands.

An estimated 38,210 acres of woodland is in private ownership in this watershed. Income from the sale of forest products is realized by most of the landowners. Forest fire protection is provided by the Virginia Division of Forestry in cooperation with the U. S. Forest Service. There are 43 landowners with flood plain land in the area benefited by the proposed structural measures in tracts ranging from 1 acre to 200 acres. Agricultural use and management of the flood plain with the present flood hazard will be limited to a medium to low level, with farm income proportionately low.

Land Treatment Data

General cover conditions in this watershed are considered to be good to fair and have improved in recent years. Areas in need of special attention are relatively small and scattered throughout the watershed. Quite a few are the results of slides caused by Hurricane Camille in August 1969. The land in the George Washington

National Forest is managed by the U. S. Forest Service. A continuing effort is being made to develop more widespread use of conservation measures by the landowners and operators. The flood hazard is limiting the management and use of over half of the flood plain land. This increases the amount of upland required for cultivated crops, adding to the erosion and sedimentation problems and tending to reduce the operating profit-margin on most farms.

About 48 percent of the farms, encompassing about 50 percent of the agricultural land in the watershed are being operated under soil and water conservation agreements with the Robert E. Lee Soil and Water Conservation District. Seventy-two operators have developed plans for their entire units; with the remaining 79 being in the process of developing complete plans. Approximately 90 percent of the practices planned to date have been applied.

Fish and Wildlife Resources

According to published records of the Virginia Commission of Game and Inland Fisheries, the only stream in the watershed which has been stocked with trout during the past five years is the North Fork of Buffalo River. This was stocked with brook, rainbow, and brown trout in 1967, 1968, 1969, and 1970. No trout stocking in this stream or any other in the watershed is planned during 1971.

Some of the headwater tributary streams within the watershed may contain populations of native brook trout. The lower reaches of Buffalo River support moderate populations of smallmouth bass and other species of sunfish. None of the stream reaches where reservoirs are contemplated presently afford any significant fishing opportunities.

The watershed presently supports good populations of squirrel, rabbit, and various non-game birds and mannals. Fair numbers of deer are present, and somewhat lower densities of wild turkey and quail. Since approximately three-fourths of the watershed area is in forest cover, probably the limiting factors in wildlife habitat are nesting cover and winter food.

This project lies in an area where almost no facilities have been developed for public outdoor recreation. Hunting and fishing in the George Washington National Forest requires a special National Forest stamp in addition to the regular State or county license. Most of the private land in the watershed is posted with access for hunting and fishing limited to local residents granted written permission on a day-by-day basis by the landowners.

## WATERSHED PROBLEMS

Revegetation of slides caused by Hurricane Camille required immediate emergency action by the landowners and operators. This was done in cooperation with a number of State and Federal agencies providing financial and technical assistance. These areas have now been largely stabilized and are being maintained as a part of the regular conservation program by the landowners. There are scattered areas in need of attention to provide improved land cover and adjust land use to its best potential. These practices include resource evaluations, crop residue management, pasture and hayland management, grassed waterways, ponds, field border plantings, tree planting and recreation area development. A continuing effort is being made to encourage more widespread application of conservation measures by landowners and operators. The needed adjustments appear to be within the financial ability of the landowners with the assistance available through current programs. Providing technical assistance to landowners to establish needed land treatment measures will be a major factor in the installation of an overall watershed management program. This will be especially true in areas which undergo change from agricultural to nonagricultural uses.

Based on stream gage records, 145 floods have occurred on Buffalo River since the gaging station was established in 1940. Thirteen floods was the largest number recorded in any one year. There have been five years in which only one flood was recorded, with no flood-free years to date. This area is subject to floods at any season of the year with the most damaging ones occurring following high intensity, short duration rainfall giving little or no warning for action to avoid losses. The most devastating storm known to have ever occurred in this area was from Hurricane Camille in August 1969. Rainfalls of up to 27 inches were reported for the period from 8:00 p.m. August 19 to 4:00 a.m. August 20. This produced a discharge at the gage on Buffalo River estimated to be about 5.5 times the discharge to be expected from a storm occurring once in 50 years. Flood stages were produced on Buffalo River which exceed the estimated 100 year frequency storm by as much as 15 feet. Damages from Camille in this watershed have been estimated locally at "in excess of $500,000", with some reports indicating as much as one and a half million dollars damage. In contrast to this, the estimated damages from a 100-year frequency storm is about $85,700.

In addition to the flood plain actually inundated by the 100-year frequency storm, there are about 100 acres of terrace bottomland above this elevation which cannot be used or managed to its most productive potential due to the flood hazard. There are another approximately 500 acres of flood plain land along the main stem of Buffalo River between the downstream limit of this watershed area and the confluence of Buffalo and Tye Rivers which have problems similar to those in the benefited area in this watershed. In the

preparation of this work plan no estimate was made of damages or potential project benefits in this downstream area.

Floodwater Damage

Storms of the five-year frequency magnitude block the road approaches and inundate four of the eight bridges in the benefited area, and nearly half of the 100-year frequency flood plain. The 100-year frequency storm blocks all the roads in the flood plain. Storm flows from large storms also carry debris, silt and other contaminants which cause various problems. Health hazards often arise when these deposits occur on the flood plain and in springs which are used as rural water supplies for one or more families. Flood blocked roads cause economic loss to residents either from long detours to market products or reach places of off-farm employment or loss of income because a sale could not be made or a place of employment could not be reached.

Flood plain land values with the present flood hazard are generally comparable to the adjacent upland where they can be used for cropland or pasture. Some of the areas which are highly vulnerable to flooding often actually tend to reduce the total value of a tract, thus are considered less valuable than the adjacent upland areas. Without the proposed project installed, additional development or more intensive use of these flood plain areas will require very expensive flood proofing measures which are not considered to be practical by the landowners.

The 100-year frequency storm inundates an estimated 793 acres in the area benefited by the structural measures proposed in this work plan. About two-thirds of the area is inundated by the 10-year storm. Landowners generally agree that flood-free agricultural production on two acres of flood plain will be at least equal to production on three acres of the best upland. Almost none of the bottomland areas presently can be managed to produce to its best potential. Average annual damages to crops and pasture amount to $8,370, of which $7,725 is from land use limitations due to flooding.

Agricultural improvements in the flood plain consists chiefly of farm roads, fences and a few small structures which vary widely in their susceptibility to damage. The average annual damage to these improvements amount to $2,405.

Major fixed improvements located in the benefited area include the water treatment plant and raw water intake for the Town of Amherst located a short distance below the confluence of Huff Creek with Buffalo River. Other improvements in the area include ready-mix concrete operation, several farmsteads, homes and miscellaneous buildings. Annual damages to these improvements amount to $4,230.

There are eight highway bridges and about 3-1/2 miles of road in the flood plain area benefited by this project. U. S. Highway 60, a major connecting link between the ports at Hampton Roads with the cities of the midwest, crosses Buffalo River just downstream from site 1B. Also U. S. 29, a major north-south highway between Washington, D. C. and Atlanta, Georgia, crosses Buffalo River in the downstream area of the watershed. The other roads and bridges are of local importance as access routes to market and off-farm employment. Damages to these improvements amount to $4,820 annually in addition to costs of traffic delays, re-routing and other indirect effects.

Recent rural non-farm growth coupled with expanded availability of public utilities and improved transportation facilities make it desirable to develop certain flood plain areas adjacent to existing highways for non-agricultural uses. Local planning bodies desire to develop these flood plain areas for residential and commercial uses to meet growing local needs. Without the proposed project, the flood hazard makes this development impractical from a cost and potential damage standpoint.

Sediment Damage

Frequent flooding deposits fine grained sediment over rather large areas of flood plain and coarser sediments at localized areas. The coarse infertile overwash damages the land directly through loss of production, and consequent loss of income to the landowner. The finer sediments deposited over larger areas cause a lesser amount of damage to productivity, but do adversely affect the quality of a number of crops. It is estimated that about 269 acres of flood plain land are experiencing reduced productive capacity due to overbank sediment deposition. This loss of production is generally about 10 percent.

Sediment deposition on roads and bridges during flood flows causes extra clean up and maintenance cost and a hazard to motorists who often come up on these thin layers of slick mud with little or no warning. Bedload movement during large flows can restrict bridge and channel capacities, lower the storage capacity of reservoirs, lower the quality of water for municipal and industrial uses, recreation, fish habitat and fishery potential and other possible future uses.

The estimated sediment yield to the James River from the Buffalo River project area is about 43,680 tons per year. This sediment causes damage along the James River and eventually some of the deposits reach the estuary at Hampton Roads. At various locations along the James River these sediment deposits result in reduced river channel capacity, loss of fish habitat, reduced water quality, esthetic degradation, and reduced navigability of the river and estuary. It is estimated that the average annual sediment damage from this source is $78,440.

## Erosion Damage

Erosion of uplands in the Buffalo River Watershed project area has been a serious problem in the past, but due to increased interest in and installation of soil conservation measures, erosion rates have been greatly reduced. Present annual gross erosion is estimated to be 7.22 tons per acre in the upland areas. Erosion continues to be a problem along road cuts and fills, on untreated cropland, in overgrazed pastures, in poorly managed woodlands; and is most severe in areas being converted to urban and industrial uses. Annual erosion rates range from 3 tons per acre in the woodland areas to 140 tons per acre for roadbanks and other nonagricultural areas. Sheet erosion continues to be the principal source of sediment.

Scouring by floodwaters in the agricultural bottom-land areas along Buffalo River and its tributaries is reducing the productive capacity of an estimated 50 acres by 20 to 40 percent annually. The estimated average annual damage attributed to flood plain scour erosion is $1,480.

## Problems Relating to Water Management

A study of the watershed did not reveal a need for project-type drainage or irrigation developments at this time.

Amherst County makes up part of the Lynchburg Standard Metropolitan Statistical Area, which also includes Campbell County and the City of Lynchburg. This area is approaching a transitional period from an agriculturally based economy to one supported more by industry and commerce.

Population projections for Amherst County indicate an increase from about 26,000 in 1970 to 34,000 by 1980 and 48,000 by the year 2000. The Amherst County Water Authority has been established to provide an adequate water system to meet the anticipated demand. Based on these population projections, consultant engineers retained by the sponsors indicate the need to increase the dependable water supply by eight million gallons a day. They report that present demands are substantially equal to the current dependable supply, and that further growth of the area depends on expansion of the present system and development of additional storage for municipal use. In order to provide for orderly development of the natural resources of the area, the consultants recommend providing storage in sites 1B and 4 for municipal and industrial use in addition to that needed for floodwater and sediment.

# PROJECTS OF OTHER AGENCIES

Long range water resource plans of Amherst County call for Buffalo River storage to be an integral part of a county-wide interconnected water system. There are no existing or proposed projects of other agencies within or outside the watershed area which will be in conflict with the works of improvement proposed in this work plan.

## PROJECT FORMULATION

The project was formulated based upon objectives agreed to with the sponsors after an inventory of the resources, problems - both cause and effect, and alternatives and combinations of alternatives that have been found to be effective in solving similar resource problems. Land treatment was considered as the first increment of treatment. Land treatment plus adjustments in land use to that consistent with the flood hazard found to exist was considered. Land treatment and various combinations of reservoir type structures was considered to solve the watershed problems and to meet the resource development objectives. Channel improvement was then considered in addition to land treatment and reservoir type structures to the extent required to give the desired level of flood protection. Alternatives considered and decisions reached during project formulation recognized the expected increase in population and the certainty of land conversions from agriculture to urban use. Objectives initially agreed to by the sponsors and the Service reflected the need to improve farm family income and preserve and improve fish and wildlife and related natural environmental values where practical. Specific objectives initially agreed to by the Sponsoring Local Organizations and the Service are detailed below.

1. A minimum of two-year frequency protection to the major portion of the agricultural flood plain.

2. Provide a 100-year frequency level of protection to the flood plains adjacent to existing roads planned for residential, commercial and industrial development.

3. A high level of protection to highways, bridges and commercial and industrial improvements in the flood plain.

4. Storage of 4,049 acre-feet of water to supplement existing supplies to meet a projected need of 8 million gallons a day to serve the domestic and industrial needs of 41,500 people by the year 2000.

5. Reduce erosion originating in the watershed by 40 percent.

The land treatment measures were formulated after an inventory of the land use, erosion and management problems that exist presently and those that are expected to develop in the future. Alternatives and combinations of measures were selected to reduce erosion, minimize farming of marginal and submarginal land, effect conservation treatment of all land, and protect the forested areas from fire. The present level of fire protection has limited the burn to less than the maximum limit of 0.07 established as a goal and is expected

to be continued in the future. Technical assistance needs are those required for the necessary soil surveys, other resource inventories, planning services, and other technical assistance for installation of the measures. Technical assistance for lands expected to undergo development for other than agricultural uses is designed to provide the level of assistance needed by planning boards to guide changes in land use and thereby minimize erosion and runoff problems from lands undergoing development. Technical assistance includes that expected to be available from going conservation programs with accelerations funded from P. L. 566 funds required to establish the planned land treatment within the selected installation period.

Adjustment in present land use and regulation of future land use within the flood plain to that consistent with the flood threat present would force abandonment of about 600 acres of flood plain now in pasture and cultivated crops to a lower order to use. The remaining flood plain land would continue to be subject to a serious flood threat. This would limit the shift of cultivated land from the marginal and submarginal uplands to the flood plains and would require an estimated additional 1,000 acres of cultivated upland to replace the flood plain. Homes, trailer courts and business as well as roads, bridges and other fixed improvements would continue to be subject to serious flood damage. This alternative was not considered practical in the face of benefits foregone in the absence of a viable flood prevention program.

Seven reservoir structure sites were identified for study to meet project objectives. Sites on Puppy Creek were eliminated after field examination because of apparent high costs, probable limited effects and impacts on the homes, roads and other fixed improvements. Sites on Huff and Tribulation Creek were eliminated after hydrologic studies showed limited effects on watershed problems. The site on Franklin Creek was eliminated because of topographic features which would result in extremely high costs clearly in excess of possible benefits. Sites on Buffalo River (1B), Thrashers Creek (2), Stonehouse Creek (3), and Mill Creek (4) were considered in detail for their effect on watershed problems. The effect of these structures on watershed problems was examined collectively, singly and in combination. These four structures were selected by this process to meet the agricultural flood prevention objectives.

The level of protection to be afforded flood plain areas with homes, trailer courts and business now in place and those areas designated in plans of the county for future development was appraised carefully. The system of structures selected to meet the objectives for protection of agricultural areas were found to give a high level of protection to areas with urban type developments thereon as well as those areas identified for future development. In

addition to the structural measures channel improvements were considered to provide the last increment of protection needed to meet the urban protection objectives. Although not evaluated in detail it was concluded that the costs of the channel improvement was greater than the urban protection benefits expected. In view of this factor and the obvious disturbance of the stream system that would be involved, channel improvement was not considered further. Since most of the urban protection objectives could be attained without channel improvements it was concluded that selective use of flood plain areas with less than a 100-year level of protection would be the better solution.

Consultant engineers, retained by the sponsors, selected structures 1B and 4 for addition of capacity for municipal and industrial water supply. Water supply capacity included in these structures will utilize the practical limits of the sites and is designed as a major segment of the future Amherst County water supply system.

The consultants had considered the James River as an alternate source of water. They found the initial costs of water from structures 1B and 4 to be less expensive than from the James River. In addition the consultants reported that costs for chemicals to treat James River water to be at least 5 times that for Buffalo River water. This storage will provide for a daily demand of 8 million gallons to supply the needs of the anticipated 17,000 increase in population.

The impact of the reservoirs on fish and wildlife values and current use of the land was considered in selecting the reservoir sites and in developing the engineering plans. Fish barriers to prevent upstream movement of bass and bream into trout waters were included as appurtenant features of sites 1B and 2 as recommended by the U. S. Fish and Wildlife Service. The fishing existing in the 5 miles of stream to be inundated, although unavailable to the public, was considered. The reservoir waters will provide a bass-bream fishing which will greatly exceed the production of the stream and will be available for public use.

Recreation needs, mainly fishing, boating and picnicking were considered jointly by the county of Amherst and the Service. The 100-year sediment pools at the single purpose sites and the median water surface in the municipal water supply pools at the multiple purpose sites were appraised for their capability for recreation use. The 400 surface acres at the four sites are expected to provide for about 36,500 visitor days for recreational use.

On the basis of this consideration the county elected to obtain land rights in fee simple title suitable to provide public access and facilities for recreation use. The facilities will be installed by the county in accordance with State and local laws and health requirements as need and use develops.

The preliminary studies for the James River Basin Survey include the measures proposed in this work plan. Final recommendations of the James River Basin Survey have not been completed.

A system of two multiple purpose structures for municipal water, floodwater and sediment storage and two single purpose floodwater retarding structures were selected as those measures most nearly meeting project objectives. The project map shows the location of these measures. There is a need to regulate the use of flood plain not provided a 100-year level of protection to discourage uses not consistent with the flood threat.

## WORKS OF IMPROVEMENT TO BE INSTALLED

Land treatment measures during project installation are mainly related to 2,300 acres of cropland, 4,695 acres of grassland, 38,210 acres of forest land and 120 acres of land in miscellaneous uses. Resource inventory and evaluation and treatment measures will consider such practices as crop residue management, contour farming, critical area planting, on-farm drainage, grassed waterways, wildlife habitat management, tree planting, protection and maintenance of existing forest cover, forest fire protection and other similar conservation measures.

The land treatment measures on private forest land include logging road stabilization on 5 miles, tree planting on 150 acres, cultural treatment measures on 4,020 acres, woodland grazing control on 2,000 acres, and skid trail and logging road protection on 200 acres. Management advice to forest landowners will consider the multiple-use aspects of forest management.

The land treatment measures on National Forest land include erosion control on 29 acres and hydrologic cultural operations on 739 acres.

Soil surveys will be completed on 49,260 acres of private land in order to properly advise landowners and operators in their land use problems.

The planning and application of measures on private land will be in cooperation with the Robert E. Lee Soil and Water Conservation District. Land treatment measures will be planned and installed on Federal land by the U. S. Forest Service. Technical assistance for planning and installation of measures on private land will be provided by the Soil Conservation Service. The Virginia Division of Forestry, in cooperation with the U. S. Forest Service, will provide technical assistance as needed for installing measures on private forest land.

### Structural Measures

Planned structural measures include two floodwater retarding structures and two multiple purpose structures, as shown on the watershed

project map. All structures will have zoned type earth fills and vegetated emergency spillways. The principal spillway for each structure will consist of a reinforced concrete drop inlet type riser with a prestressed concrete pipe.

All structures are designed to pass the 100-year frequency runoff through the principal spillway without emergency spillway flow. The four structures will provide 9,630 acre-feet of flood storage and will control 28,155 acres (43.98 square miles), or 46.5 percent of the total watershed area. The floodwater detention capacity is equivalent to 4.10 inches of runoff from the area above structures, or 1.91 inches from the entire watershed area. Storage capacity will be provided for the 100-year sediment volume in each structure. Total sediment capacity for all structures will be 2,619 acre-feet. The two multiple purpose structures will store 4,049 acre-feet of water supply for Amherst County.

During construction appropriate measures will be taken to minimize soil erosion and water and air pollution. These measures will be determined on a site by site basis by evaluating the pollution hazard in relation to established standards for the area in question.

In preparing plans and specifications for structures at locations where pollution tolerances may be exceeded, control of erosion and sedimentation will be accomplished through such measures as temporary vegetation or mulch on exposed areas; reduce to the greatest extent practical duration of exposure of highly erodible soils; complete and protect project segments as rapidly as construction schedules will permit; trap sediment in debris basins; employ measures to keep erosion under control if construction is suspended for an appreciable length of time and use of temporary bridges or culverts where fording of the stream during construction is objectionable.

Contractors will be required to manage the construction activities so as to either eliminate or minimize within tolerable limits the effects of pollution from sources such as dust, open fires, trash, noise, etc.

Installation of the four dams will require the purchase of, or flowage easements on, 719 acres of land. This includes 296 acres for site 1B involving six landowners and acquiring 3 houses and various other fixed improvements. One family will be displaced from an owner occupied dwelling and three families from tenant occupied dwellings. Construction of dam 2 will require 88 acres involving two landowners and the relocation of one family in a rented house. Construction of dam 3 will require 96 acres of land involving three landowners, with no known residences involved or relocations necessary. Installation of dam 4 will require 239 acres of land involving 13 owners and will require relocation of two mobile homes and families in two rented dwellings.

Current land use in the areas to be inundated by the conservation and water supply pools is 293 acres of cropland, 96 acres of pasture and 40 acres in idle and miscellaneous uses. Land use in the flood detention pool areas is currently 195 acres of cropland, 68 acres of pasture, and 27 acres in idle and miscellaneous uses (mostly farmstead lots and roads).

Relocation of farm operations or businesses will not occur as a result of land rights acquisitions for installation of this watershed project.

Design data for all structures is shown in table 3. Features peculiar to each site were considered and recommendations are made under individual site headings below.

Structure No. 1B (Main Stem) - This site is located on the main stem of Buffalo River approximately 1.3 miles upstream from Highway No. 60. It has a drainage area of 24.07 square miles. This structure will provide 2,000 acre-feet of water supply storage, 5,348 acre-feet of floodwater storage, and 1,309 acre-feet of sediment storage. The structure will have two vegetated emergency spillways, 300 feet around the left abutment and 250 feet around the right abutment. A dike, designed to contain the freeboard flow, will be constructed along the inside edge of the left spillway, and will extend beyond the downstream toe of the dam. The stilling basin for the principal spillway will consist of a chute spillway with a SAF outlet, and a transition section between the pipe invert and chute section.

The dam will be about 85 feet high and will be constructed of approximately 712,900 cubic yards of fill, including about 671,000 cubic yards of compacted earth and about 41,900 cubic yards of rock. The two emergency spillways will yield about 303,200 cubic yards of earth fill, and about 367,900 cubic yards will come from the left abutment and pool area. The spillway borrow will range from GM to CH, with SM to ML predominating. The pool area borrow will range from GP to GM. Borrow from the left abutment will be SM to ML.

A cutoff trench will be excavated to relatively impermeable foundation material consisting of slightly weathered to unweathered gneiss and granite. Additional material, consisting of 4,400 cubic yards of rock and 7,700 cubic yards of common, will be excavated from the narrow left abutment as a precaution against possible leakage. The principal spillway will rest on a yielding foundation, and the pipe trench will be excavated to a depth of approximately 7 feet and backfilled with suitable borrow material.

A fish barrier, a rock-filled gabion similar to a type b drop structure, will be installed upstream from the structure to preclude upstream movement of fish. The use of a gabion structure is consistent with the pH of the water, sediment movement and the desires of the sponsors. With the channel on bed-rock no problems of stability are anticipated.

Structure No. 2 (Thrashers Creek) - This site is located on Thrashers Creek approximately 0.4 mile upstream from Highway No. 610. It has a drainage area of 6.80 square miles. The structure will have 1,274 acre-feet of floodwater storage and 477 acre-feet of sediment storage. The structure will have a 300 foot vegetated emergency spillway around the left abutment. A plunge pool outlet will serve as a stilling basin for the principal spillway.

The dam will be about 69.5 feet high and will be constructed of approximately 252,700 cubic yards of fill, including about 233,100 cubic yards of compacted earth and about 19,600 cubic yards of rock. The emergency spillway cut will yield about 91,900 cubic yards of earth fill, and about 141,200 cubic yards will come from the left abutment and pool area. Borrow material will range from GM to ML with SM predominating. A shallow cutoff trench should eliminate any leakage problems. The principal spillway will rest on a yielding foundation, and the pipe trench will be excavated to a depth of approximately 7 feet and backfilled with suitable borrow material. A rock-filled gabion structure, similar to that described in site 1B, will be installed upstream from this floodwater retarding structure. No stability problems are anticipated since the channel is on bed rock.

Structure No. 3 (Stonehouse Creek) - This site is located on Stonehouse Creek approximately 0.5 mile upstream from Highway No. 610. It has a drainage area of 4.99 square miles. The structure will have 1,030 acre-feet of floodwater storage and 399 acre-feet of sediment storage. The structure will have a 150 foot vegetated emergency spillway around the left abutment. The principal spillway will have a plunge pool outlet.

The dam will be about 55.5 feet high and will be constructed of approximately 64,900 cubic yards of fill, including about 55,500 cubic yards of compacted earth and about 9,400 cubic yards of rock from the emergency spillway and abutment areas. The emergency spillway cut will yield about 63,300 cubic yards of earth fill; therefore, no additional borrow should be necessary. The fill material from the emergency spillway is mostly SM with some ML and GM. A cutoff trench will be excavated to foundation material consisting of slightly weathered to unweathered gneiss. The cost estimate includes 1,000 cubic yards of rock excavation for site preparation, mainly for the removal of weathered rock from the right abutment. The principal spillway will rest on a non-yielding foundation.

Structure No. 4 (Mill Creek) - This site is located on Mill Creek approximately 0.5 mile upstream from Highway No. 610. It has a drainage area of 8.12 square miles. This structure will provide 2,049 acre-feet of water supply storage, 1,978 acre-feet of floodwater storage, and 434 acre-feet of sediment storage. The structure will have a 250 foot vegetated emergency spillway around the right abutment. A plunge pool outlet will serve as a stilling basin for the principal spillway.

The dam will be about 55.0 feet high and will be constructed of approximately 99,600 cubic yards of fill, including about 92,200 cubic yards of compacted earth and about 7,400 cubic yards of rock. The emergency spillway cut will yield about 53,200 cubic yards of earth fill, and about 39,000 cubic yards will come from the pool area. Fill material from the emergency spillway excavation is mostly SM with some ML and GM. Borrow material from the pool area is mainly ML and SM with some GM and CL.

A cutoff trench will be excavated to relatively impermeable foundation material consisting of weathered to slightly weathered granite and gneiss. The deep cutoff on the right abutment should eliminate any leakage problems due to the deeply weathered and jointed rock conditions. The principal spillway will rest on a yielding foundation, and the pipe trench will be excavated to a depth of approximately 7 feet and backfilled with suitable borrow material.

Amherst County, separate and apart from this plan, will stock all four impoundments with fish and provide for public access to these sites. This will provide a total of about 400 surface acres at the four sites which the county plans to open for bank and row boat fishing - no gasoline powered boats allowed. The Sponsors will locate, install, operate and maintain sanitary facilities as required by State and local health agencies to allow their use for fishing and picnicking. The cost of these measures and their operation and maintenance will be derived from use charges. The use charges will not exceed the rate required to return the county's investment plus operation and maintenance costs.

## EXPLANATION OF INSTALLATION COSTS

Estimated project costs for both land treatment and structural measures are shown in table 1. Structural measure cost estimates are shown in greater detail in table 2, with allocation between purposes and sharing of estimated costs between P. L. 566 and other than P. L. 566 funds in table 2A. The cost sharing percentages for structural measures shown in the agreement will be the basis for sharing the actual costs incurred at the time of installation. These cost sharing percentages are based upon the purposes involved in each structure, law and policy, and the estimated costs.

### Land Treatment Measures

The estimated cost for land treatment measures including technical assistance and installation costs shown in table 1 are based upon recent experiences in installation of similar measures. The total estimated costs are $406,585 which includes $15,200 for the National Forest and $391,385 for non-federal land. The $15,200 for federal land includes $12,300 from anticipated going program funds of the U. S. Forest Service and $2,900 from supplemental funds to be requested by that agency for this purpose. The $391,385 for non-federal land includes $229,185 for installation of the land treatment measures. The Virginia Division of Forestry will use $8,000

of regular funds and services valued at $1,500 through the going Cooperative Forest Management program. Public Law 566 funds in the amount of $34,100 for soil surveys, and $80,700 for technical assistance will be used by the Soil Conservation Service to insure adequate technical assistance to provide for installation of planned land treatment measures and land use changes.

Public Law 83-566 funds in the amount of $39,400 will be used by the U. S. Forest Service through cooperative programs with the Virginia Division of Forestry for technical assistance to accelerate installation of forestry practices on private land.

Structural Measures

The estimated cost for each structure is made up of construction, engineering services, land rights and relocation costs. Project administration costs, estimated to be $179,300 are applicable to all project measures rather than a specific site. Project administration costs include the cost of contract administration, review of engineering plans prepared by others, Government Representatives, necessary inspection service during construction, and the costs for relocation assistance advisory services. Estimated costs for construction, engineering services, land rights, relocation costs and project administration are based upon recent experiences in installation of similar measures under similar conditions from detailed estimates.

Construction costs are based on bid item schedules from preliminary designs and applicable unit prices from recently completed work in Virginia, plus a 12 percent contingency allowance.

The construction costs for sites 2 and 3, single purpose floodwater retarding structures, are estimated to be $293,600 and $146,800, respectively. A rock filled gabion structure, estimated to cost $4,600 is included in the cost estimate for site 2.

The construction costs for sites 1B and 4, multiple purpose flood control and water supply structures, are estimated to be $751,500 and $223,900, respectively. These costs include $10,000 at site 1B and $9,000 at site 4 for the raw water intake structures which are for the specific purpose of water supply. The estimated cost for the rock-filled gabion structure above site 1B is $5,700. Special foundation preparation measures to minimize leakage and insure stability in addition to normal cutoffs are estimated to cost $17,050 at site 1B and $2,600 at site 4.

Engineering services cost for sites 2 and 3 are estimated to be $17,970 and $9,000, respectively. These costs, in addition to the usual costs for survey, design and preparation of plans and specifications include $6,220 at site 2 and $3,120 at site 3 for geologic investigations. These investigations will consist of surface and subsurface investigations and sampling of the materials present by means of a backhoe and core drill where necessary.

Land rights costs for each site were estimated by the sponsors' land rights committee and include those fee simple titles and flowage easements necessary for the pool areas, floodwater capacity, emergency spillway, the reservoir and dam including construction zone and for public access. Options to purchase or provisions for flowage easements have been obtained from 22 of the 24 landowners who own property in areas which will be affected by the construction of the four dams. Land rights costs are estimated to be $461,786. Total relocation payments are estimated at $15,164 for the eight families involved.

Sites 2 and 3 are for single purpose flood prevention. The sponsors will provide all land rights costs for these structures. The Service, from P. L. 566 funds, will provide all construction and engineering services costs.

The joint construction, engineering and land rights costs for structures 1B and 4 are allocated between the purposes of flood prevention and municipal water supply on the basis of storage capacity provided for each purpose. The specific construction and engineering costs for the raw water intake structures in each structure are for the specific purpose of water supply and are allocated to that purpose. On this basis 76.9 percent of the joint costs for site 1B were allocated to flood prevention and 23.1 percent to municipal water supply. Similarly, 54.0 percent of the joint costs of site 4 were allocated to flood prevention and 46.0 percent to municipal water supply. The sponsors will provide all land rights costs for sites 1B and 4. The Service will bear 76.9 percent of the joint construction costs and the county will provide 23.1 percent for site 1B. The Service will bear 54.0 percent of the joint construction costs for site 4 and the County will provide 46.0 percent of these costs. The County will provide 100 percent of the construction costs associated with the raw water intake structures at sites 1B and 4.

The engineering services for site 1B and 4 covering both joint and specific construction cost items will be secured by the sponsors through A&E contracts. The County will pay 100 percent of the engineering costs associated with the raw water intake structure in each contract. The Service will pay 76.9 percent of the costs associated with joint construction items for site 1B and 54.0 percent for site 4. The County will provide 23.1 percent of the engineering services costs associated with the joint construction items for site 1B and 46.0 percent for site 4.

Relocation costs will be shared by the Service and the County on the basis of the total project costs less the relocation costs; except that the Service will pay for the first $25,000 of costs associated with each relocation that occurs before July 1, 1972. Sharing of relocation costs shown in this plan amount to 42.1 percent sponsors cost and 57.9 percent Service cost since the relocations are not likely to occur prior to July 1, 1972. The County

will provide all costs for Relocation Advisory Assistance Service. In the multiple purpose structures, relocation costs were considered as joint costs and allocated to the purposes served in each structure.

Project administration costs of the sponsors and the Service are estimated to be $34,455 and $144,845, respectively and represent the costs each will incur for services they provide. The sponsors' estimated project administration costs include contract administration costs $750 and the costs for relocation assistance advisory services of $1,000 in addition to the costs for inspection services, clerical and other administrative services they provide. Project administration services will include those costs incurred by Amherst County in serving notice of displacement, providing appropriate application forms, assisting in filing applications, hearing and resolving grievances, and in making relocation payments. The Service will bear the costs they incur and will assist the sponsors in providing these services.

The sponsors have established a six-year project installation period. The estimated obligation of funds, including land treatment and structural measures, for each fiscal year during the installation period is as follows:

| | P.L. 566 Funds | | Other Funds | | | |
|---|---|---|---|---|---|---|
| | Structural | Land | Structural | Land Treatment | | |
| Year | Measures | Treatment | Measures | Supp. USFS | All Other | Total |
| 1 | 34,022 | 25,700 | 149,218 | - | 41,580 | 250,520 |
| 2 | 136,240 | 25,700 | 115,540 | 580 | 41,580 | 319,640 |
| 3 | 630,063 | 25,700 | 463,077 | 580 | 41,580 | 1,161,000 |
| 4 | 176,965 | 25,700 | 40,650 | 580 | 41,585 | 285,480 |
| 5 | 338,020 | 25,700 | 37,655 | 580 | 41,580 | 443,535 |
| 6 | 25,000 | 25,700 | 3,000 | 580 | 41,580 | 95,860 |
| TOTAL | 1,340,310 | 154,200 | 809,140 | 2,900 | 249,485 | 2,556,035 |

## EFFECTS OF WORKS OF IMPROVEMENT

Accelerated soil surveys and other resource inventories will provide basic information needed by the landowners and operators planning land use changes and improved conservation measures.

Installation of this project will provide immediate benefits to the 3,500 people now living in the Buffalo River watershed and for the 16,000 to 18,000 additional people expected to be living there in the next 25 to 30 years.

Land treatment measures have been selected to aid in the reduction of runoff, erosion and sedimentation, maintain natural qualities and provide for improvement consistent with proper land use and environmental quality. Conservation measures are planned for 2,300 acres of cropland, 4,695 acres of grassland, and 120 acres of miscellaneous land.

An improved hydrologic condition will result from the improvement and protection of vegetative cover. Forest cover is very important in maintaining an improved hydrologic condition. Proper management and continued fire protection will enhance the hydrologic condition, increase productivity of forest products, wildlife, recreation and environmental quality.

Protection of the flood plain lands will make it possible for landowners to manage their operations more effectively. Land use adjustments to use a high level of management on a greater portion of the flood plain for cultivated crops will provide the grain and forage needed for on-farm use and reduce the acreage of upland with marginal production potential used for these crops. This and other improved management practices made possible by the project is expected to result in reducing the number of farms with gross sales of less than $5,000 from 280 to about 170 and will improve employment opportunities for about 100 local agricultural workers.

Installation of the project will permit 43 present landowners to more fully and effectively use 750 of the 793 acres of flood plain land in the benefited area in the watershed. In addition to protecting 150 acres of reaches A, C, D, and G sufficiently to allow residential and commercial development, about 600 acres will be adequately protected for a more efficient agricultural use. The opportunity for improved use and management of about 100 acres adjacent to the benefited area in the watershed will also be enhanced by the project. This will permit use of improved crop varieties, larger amounts of fertilizer, more timely seeding and harvesting and other cultural practices which tend to improve the operating efficiency and farm income. The other approximately 3,450 people in the watershed and about 5,000 other nearby county residents will enjoy the benefits of fewer blocked and damaged roads, less loss of income, reduced sediment load in the stream and a generally improved environment.

This project will reduce the flood damages to major flood plain improvements from the 100-year frequency storm from about $30,000 to $6,400. The frequency of beginning damage to improvements in this area will be reduced from about the two-year frequency to once in 5 years. The area flooded by the 100-year event will be reduced by 311 acres, from 793 to 482 acres; the 5-year event by 318 acres, from 369 acres to 51 acres; with flooding by the 2-year event reduced from 90 acres to 8 acres located in scattered areas of the lower elevations which are expected to remain mostly in woods.

The 72 acres of flood plain in reaches A and D will receive 100-year frequency protection. Forty of the 70 acres of flood plain in reach C will receive 100-year frequency protection, with a maximum flood depth of 0.6 feet anticipated on the remaining 30

acres. Fifty-four of the 73 acres in reach G will receive 100-year frequency protection, with a maximum depth of 1.7 feet on the remaining 19 acres. Thirty-five acres adjacent to existing roads in this reach are planned for nonagricultural use, with the remainder planned for continued agricultural use. Development of these areas should be limited to uses consistent with the remaining flood hazard. These uses might include recreation areas, agriculture, parks, etc. A strip map is included in this work plan to aid in development of these areas.

A committee familiar with local conditions estimates that with the project installed flood plain land values will increase to an average of about $750 per acre for a higher level of agricultural use and to $2,500 to $3,000 per acre where protected sufficiently for planned nonagricultural development. With increased potential for off-farm employment, it is anticipated that the income of operators of small family-type and part-time farms will be materially improved.

Erosion rates in the upland areas will be reduced by conservation land treatment to an estimated 5.7 tons per acre annually. With land treatment and structural measures installed, the sediment yield from the Buffalo River project will be reduced to about 21,355 tons annually. The net reduction in sediment yield is about 22,326 tons annually. Approximately 6,266 tons annually of this reduction is due to conservation land treatment. The remaining 16,060 tons annually results from the installation of planned structural works.

Sediment damages downstream from the Buffalo River along the James River will be reduced by about 51 percent. This will result in increased river channel capacity, higher quality fish habitat, improvement of esthetics and increased navigability of the river and estuary.

Damages resulting from flood plain scour will be reduced by about 70 percent as a result of project installation.

Overbank sediment deposition will be reduced by about 84 percent. The productive capacity of 269 acres of flood plain soils will return to normal.

Presently about 1/3 of the people in the watershed are served by the municipal water system operated by the Town of Amherst. Installation of this project will provide this service to half to two-thirds of the present residents. Population projections indicate that the Buffalo River watershed area will increase by about 6,000 to 8,000 by 1980 and by another 16,000 to 18,000 by the year 2000. To serve this population it will be necessary to increase the available water supply. Amherst is currently using Buffalo River as a source of raw water for their municipal system, with treatment facilities at the water intake location. No problem of pollution or water quality is anticipated from development of this project. Development of the water storage

will provide conditions needed for economic growth and improved employment opportunities in the area. Municipal storage in this project is planned as part of a county-wide water system expected to serve almost 50,000 people in the next 30 years. Development at this time will allow additional time for design and development of other sources needed for the expected future growth.

A mining and pigment processing operation employing 400 people in the adjacent Tye River watershed in Nelson County was recently closed due to pollution and other environmental problems. Some of these people live in the Buffalo River watershed. The water storage and flood protection provided by this project will create conditions which are expected to help offset this employment loss. Thirty to 40 jobs will be created for the 6-year project installation period to install the project measures. Ten to 20 permanent jobs will be created and will continue throughout the project evaluation period to use, operate and maintain the facilities of the project measures. Three hundred to 400 jobs are expected to result from commercial and industrial expansion or development in the watershed by 1980. It is also possible that another 100 to 200 support type and service jobs will be created as a result of the project.

The 300 acres of wildlife habitat management planned as land treatment measures will enhance the habitat for upland wildlife. Public ownership of the four dams and adjacent areas, together with access and sanitary facilities, will materially improve opportunities for water oriented public recreation. Incidental recreation activities of this nature are expected to accommodate about 36,550 user days annually. The addition of 400 surface acres of impoundments which will be stocked and open to public fishing will considerably enhance the fisheries resources of the watershed. Due to drawdown for other uses of the reservoirs, the average surface area available for fishing waters will probably be about 300 acres. Under the expected type of management this water should produce annual harvests of between 30 and 40 pounds of fish per acre. About 20 to 25 percent, by weight, of the fish harvested will be largemouth bass and the remainder blue gill and other sunfishes. Weirs are to be installed above two of the impoundments (sites 1B and 2 on project map) to prevent damage to trout waters above by centrachid invasion. Since no alteration of the present stream channels is planned, downstream fisheries will not be affected.

Inundation by the conservation pools of the proposed reservoirs will be on land which is presently about two-thirds cropland and one-third pasture. This change in land use will probably have no noticeable effect on the carrying capacity of the watershed for upland game. These pool areas will provide additional resting areas for migrating waterfowl, and if properly managed, the reservoirs and adjacent areas may induce some ducks and geese to spend winters there. In providing the 400 acres of lake surface at the four structure sites about 5 miles of stream channel will be inundated. This area currently provides very limited bass fishing since most of the area is posted. Two hundred sixty acres, mostly cropland and pasture, will be flooded intermittently during passage of flood flows. Except for those areas to be set aside for public recreation, these areas are expected to be in permanent vegetative cover.

The U. S. Forest Service will continue to manage the Federal lands in the watershed with adequate consideration to wildlife management, proper public use and environmental quality.

Relocations resulting from land rights acquisitions described in this work plan will not result in major socio-economic changes in the watershed. It is anticipated that the owner-occupied dwelling to be acquired in connection with the construction of dam 1B will be replaced with a new safe and sanitary dwelling on the owner's remaining land and will contain more modern conveniences than the dwelling presently occupied. Other replacement dwellings will be generally comparable to the rental dwellings in the area and at least meet the "decent, safe, and sanitary" requirements as required in regulations to conform to the requirements of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970.

## PROJECT BENEFITS

The average annual value of benefits from structural measures is estimated to be $223,955. Annual floodwater damage reduction benefits to structural measures amount to $58,785. The annual value of land treatment flood damage reduction benefits is estimated to be $12,990.

Structures selected during project formulation provide a high degree of control to a major portion of the flood plain. Most existing improvements are located in the upper elevations of the flood plain which now will also receive a relatively high degree of protection. Tables 5 and 6 give details of the project benefits.

Floodwater damage reduction benefits to crops and pasture total $8,120, of which $7,725 is the result of restoration to former productivity level and is included as a crop and pasture damage in table 5. Other agricultural benefits amount to $1,900 and result from reduction of damages to fences, water gates, farm roads and other similar improvements.

Flood plain sediment and erosion damage reduction benefits are estimated to average $42,905 annually, of which $1,785 is from reduced overbank deposition, $1,030 from reduced flood plain scour and $40,090 from reduced sediment damages downstream in the James River and its Hampton Roads Estuary.

Reduction of damage to highways, bridges, and other major flood plain improvements amounts to $7,855 annually.

Indirect benefits amount to $10,995 annually. These are the result of the reduction of such items as power failures, late feed deliveries, delayed marketing, loss of work, interrupted public services, increased expenses of detouring traffic and other such losses associated with flooding.

Flood protection provided by this project will make it possible for landowners to use their flood plain lands and some areas adjacent to them more intensively. Both the flood plain and upland areas along U. S. Highway 60 and Virginia 778 are coming under increasing pressure for residential and commercial development. Farm operators will also have more freedom in selecting proper soil and slope conditions for their various crops. Use of improved varieties, larger amounts of higher analysis fertilizers and other improved management practices will be practical. More intensive use benefits on agricultural land are estimated at $19,250 annually after allowing for the associated costs for development and production. Benefits to changed land use for planned nonagricultural purposes amounts to $25,400 annually.

Based on information from the sponsor's consultant engineers, benefits to municipal water storage in dams 1B and 4 amount to $71,165 annually.

Local secondary benefits induced by the project are considered to be 10 percent of the costs that primary producers will incur in connection with production of goods and services as a result of the project and amount to $1,230 annually. These benefits include increased net return to suppliers of equipment and supplies, local retailers and wholesalers from consumer expenditures resulting from increased income and other returns from expenditures directly associated with the production,marketing and using project goods and services. Local secondary benefits stemming from the project result from greater use of transportation, processing and marketing facilities, tending to increase both agricultural and general business activities. Use of nonagricultural water storage from dams 1B and 4 will add to the economic growth of the area. These benefits amount to $7,955 annually.

Secondary benefits from a national viewpoint were not considered pertinent to the economic evaluation of this watershed. The proposed project measures will contribute substantially to the aesthetic and environmental values throughout the watershed. By providing additional good quality municipal water the homes and businesses of the area will be provided with a basic community necessity for adequate public health standards, full employment, a growing economy and an improved environment.

With nearly half of the drainage of the watershed area controlled, the danger of loss of life from flooding in the benefited area, with normal precautions for personal safety is virtually eliminated.

Use of the lakes and adjacent areas by Amherst County for public fishing and water oriented recreational activities as a non-project feature will provide incidental recreation benefits estimated at $40,170 annually.

## COMPARISON OF BENEFITS AND COSTS

The average annual cost of structural measures is estimated to be $121,656. Annual primary benefits from planned structural measures, which exclude local secondary benefits, are estimated to be $214,770 giving a benefit-cost ratio of 1.8 to 1.0. The inclusion of local secondary benefits and incidental recreation benefits increases the estimated average annual benefits to $223,955, and the benefit-cost ratio to 1.8 to 1.0. Table 6 summarizes the annual benefits and costs.

## PROJECT INSTALLATION

The Robert E. Lee Soil and Water Conservation District and the Amherst County, Virginia Board of Supervisors, the Sponsoring Local Organizations, will be responsible for the successful application of this plan. Their responsibilities will be supplemented by memoranda of understanding and cooperative agreements with other agencies and organizations.

An installation period of six years has been established for measures proposed in this plan. Land treatment measures will be installed more or less uniformly over the project installation period. The proposed sequence of installation of structural measures is as follows: multiple purpose structure No. 4 and 1B; floodwater retarding structures 3 and 2. While this order of construction is desired, it may be altered by the sponsors within the limits of this plan.

### Land Treatment Measures

The U. S. Forest Service will install the forestry measures on national forest land. The Robert E. Lee Soil and Water Conservation District will assume the responsibility for coordinating installation of land treatment phases of this plan on non-Federal land. This responsibility will be carried out through memoranda of understanding with other agencies and organizations.

Landowners and operators will be encouraged to apply and maintain the needed measures and treatment identified for their land. The Soil Conservation Service will provide technical assistance to complete 49,260 acres of soil surveys and assistance to landowners and operators in the planning and application of needed measures. The Virginia Division of Forestry, in cooperation with the U. S. Forest Service, will provide technical assistance in the planning and application of forestry measures on non-Federal land as requested.

The Amherst County Agricultural Stabilization and Conservation Committee, through the Rural Environmental Assistance Program will assist in accelerating the completion of planned land treatment

measures. This assistance will be in the form of approval of requests for REAP cost-sharing for practices to be carried out on farms in the watershed. Assistance will be limited to the amount of funds available under REAP and by the needs and desires of the landowners.

Structural Measures

The structural measures in this plan are made up of two multiple purpose structures for floodwater, sediment and municipal storage and two floodwater retarding structures.

Amherst County will secure all land rights in fee simple or through easement necessary for construction of the structures and for public access. Options have been secured for purchase of nearly all the necessary land rights. The County has the right of eminent domain and agrees to use this right if necessary to secure the remaining necessary land rights.

In securing the land rights the County will meet applicable requirements of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 with respect to acquisition, relocation of displaced persons, businesses, and farm operations. The County will provide relocation assistance advisory services and provide relocation payments consistent with the Act.

The sponsors have determined that decent, safe, and sanitary replacement housing will be available for all persons subject to displacement by the project and that displaced persons will be given notice to vacate at least 90 days before they have to move.

The Soil Conservation Service will provide the engineering services needed for surveys, investigation, design and preparation of plans and specifications for floodwater retarding structures 2 and 3.

Amherst County will negotiate A&E contracts with engineering consultants acceptable to both the County and the Service for surveys, investigations, designs and preparation of plans and specifications for sites 1B and 4.

Amherst County will let and administer construction contracts, provide inspection services they deem necessary to insure that the installations conform with contract requirements including inspection services they require to assure proper functioning of the water supply features. The County at a later date may request the Service to administer contracts.

The Service will at P. L. 566 cost service the A&E contracts and provide construction inspection for all items on which P. L. 566 funds are spent. The Service will also inspect other items of work when malfunction or failure could adversely affect the stability or functioning of cost shared items of work.

At least 50 percent of all farm land above each dam will be under cooperative agreement before construction is initiated.

## FINANCING PROJECT INSTALLATION

The costs, $223,485 for application of land treatment on private land will be from the resources of landowners and operators with cost sharing assistance available under going conservation programs. Cooperative forest fire protection, estimated to cost $4,585, will continue to be financed through going conservation programs. The costs for land treatment on the national forest land will be financed from going program funds of the Forest Service ($12,300) and from supplemental funds ($2,900). The U. S. Forest Service will request a supplemental appropriation in the amount of $2,900.

Technical assistance now available through going conservation programs will be continued at about the same rate that existed prior to the development of this plan. This cost is estimated to be $23,200. The Soil Conservation Service will use $13,700 from going program funds, and the Virginia Division of Forestry will use $8,000 of regular funds and services valued at $1,500, through the going Cooperative Forest Management Program. The costs, about $154,200 for accelerated technical assistance including soil surveys will be financed from P. L. 566 funds. Of this amount, the U. S. Forest Service will use $39,400 in cooperation with the Virginia Division of Forestry and the Soil Conservation Service will use $114,800.

Amherst County will provide the non-Federal share of the project costs for structural measures estimated to be $809,140 from its regular sources of revenue. This includes the costs for municipal water supply which is not eligible for P. L. 566 cost-sharing. The County has analyzed the installation schedule and its financial needs so that funds will be available at the time and in the amount required.

This work plan does not constitute a financial document to serve as the basis for obligation of Federal funds. Public Law 566 funds will be provided from funds appropriated for that purpose.

## PROVISIONS FOR OPERATION AND MAINTENANCE

Land treatment measures on non-Federal land will be operated and maintained by the landowners and operators through cooperative agreements with the Robert E. Lee Soil and Water Conservation District. Land treatment measures on Federal land will be maintained by the George Washington National Forest of the U. S. Forest Service.

Amherst County will be responsible for the operation and maintenance of all structural measures including the raw water intake systems for sites 1B and 4 and the fish barriers above dams 1B and 2 at an estimated cost of $5,500 annually. This will consist primarily of mowing, liming and fertilizing the dam and spillway, seeding and mulching of bare areas, repairing gullies that may occur in the dam area and painting the trash racks. In addition it may be necessary to replace elements of the structures such as the trash rack and upstream fish barriers during the useful life of this project.

Facilities provided for recreational use will be operated and maintained by the County. This will consist primarily of proper maintenance of the sanitary facilities required by State and local health regulations, fences, access roads, parking lots and general conditions of the area.

The designated representatives of the Service and the sponsors will make a joint inspection annually, after severe floods, and after the occurrence of any other unusual conditions that might adversely affect the structural measures. These inspections will continue for 3 years following the installation of each structural measure. Inspections after the third year will be made by the sponsors. They will prepare a report and send a copy to the Service employee responsible for O & M inspection follow-up. These reports will be thoroughly reviewed by the Service representative. Any evidence of needed inspections or maintenance not being performed properly will be reported immediately and appropriate action taken by the responsible sponsors. All maintenance agreements will be properly completed before execution of project agreements.

Buffalo River Watershed, Virginia

| Installation Cost Item | Unit | Number Fed. Land | Number Non-Federal Land | Number Total | Estimated Cost (Dollars) 1/ P.L. 566 Funds Fed. Land | P.L. 566 Funds Non-Fed. Land | P.L. 566 Funds Total | Other Fed. Land | Other Non-Fed. Land | Other Total | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LAND TREATMENT | | | | | | | | | | | |
| Soil Conservation Service | Ac. | | | | | | | | | | |
| Cropland | to be | | 2,300 | 2,300 | | | | | 10,100 | 10,100 | 10,100 |
| Grassland | Treated | | 4,695 | 4,695 | | | | | 122,700 | 122,700 | 122,700 |
| Miscellaneous Land | | | 120 | 120 | | | | | 15,100 | 15,100 | 15,100 |
| Technical Assistance | | | | | | | | | | | |
| Planning & Application | | | | | | 80,700 | 80,700 | | 13,300 | 13,300 | 94,000 |
| Soil Surveys | | | | | | 34,100 | 34,100 | | 400 | 400 | 34,500 |
| SCS Subtotal | | | | | | 114,800 | 114,800 | | 161,600 | 161,600 | 276,400 |
| Forest Service | | | | | | | | | | | |
| Forest Land | Ac. | 739 | 6,370 | 7,109 | | | | 12,300 | 59,900 | 72,200 | 72,200 |
| Critical Areas | to be | 29 | 6 | 35 | | | | 2,900 | 1,600 | 4,500 | 4,500 |
| Coop.Forest Fire Prot. | Treated | | 38,210 | 38,210 | | | | | 4,585 | 4,585 | 4,585 |
| Technical Assistance | | | | | | 39,400 | 39,400 | | 9,500 | 9,500 | 48,900 |
| FS Subtotal | | | | | | 39,400 | 39,400 | 15,200 | 75,585 | 90,785 2/ | 130,185 |
| TOTAL LAND TREATMENT | | | | | | 154,200 | 154,200 | 15,200 | 237,185 | 252,385 | 406,585 |
| STRUCTURAL MEASURES | | | | | | | | | | | |
| Construction | | | | | | | | | | | |
| Soil Conservation Service | | | | | | | | | | | |
| Floodwater Retarding | | | | | | | | | | | |
| Structures | No. | | 2 | 2 | 440,400 | 440,400 | | | | | 440,400 |
| Multiple Purpose Struc. | No. | | 2 | 2 | 686,255 | 686,255 | | | 289,145 | 289,145 | 975,400 |
| Subtotal - Construction | | | | | 1,126,655 | 1,126,655 | | | 289,145 | 289,145 | 1,415,800 |
| Engineering Services | | | | | | | | | | | |
| Soil Conservation Service | | | | | | 60,030 | 60,030 | | 17,370 | 17,370 | 77,400 |
| Subtotal - Engineering | | | | | | 60,030 | 60,030 | | 17,370 | 17,370 | 77,400 |

# TABLE 1 - ESTIMATED PROJECT INSTALLATION COST

Buffalo River Watershed, Virginia

| Installation Cost Item | Unit | Number Fed. Land | Number Non-Fed. Land | Number Total | Estimated Cost (Dollars) 1/ P.L. 566 Funds Fed. Land | P.L. 566 Funds Non-Fed. Land | P.L. 566 Funds Total | Other Fed. Land | Other Non-Fed. Land | Other Total | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Relocation Payments | | | | | | | | | | | |
| Soil Conservation Service | | | | | | 8,780 | 8,780 | | 6,384 | 6,384 | 15,164 |
| Subtotal - Relocation | | | | | | 8,780 | 8,780 | | 6,384 | 6,384 | 15,164 |
| Project Administration | | | | | | | | | | | |
| Soil Conservation Service | | | | | | | | | | | |
| Relocation Assistance Advisory Services | | | | | | | | | 1,000 | 1,000 | 1,000 |
| Construction Inspection | | | | | | 64,145 | 64,145 | | 14,950 | 14,950 | 79,095 |
| Servicing A&E Contract | | | | | | 5,000 | 5,000 | | | | 5,000 |
| Other | | | | | | 75,700 | 75,700 | | 18,505 | 18,505 | 94,205 |
| Subtotal-Administration | | | | | | 144,845 | 144,845 | | 34,455 | 34,455 | 179,300 |
| Other Costs | | | | | | | | | | | |
| Land Rights | | | | | | | | | 461,786 | 461,786 | 461,786 |
| Subtotal-Other | | | | | | | | | 461,786 | 461,786 | 461,786 |
| TOTAL STRUCTURAL MEASURES | | | | | | 1,340,310 | 1,340,310 | | 809,140 | 809,140 | 2,149,450 |
| TOTAL PROJECT | | | | | | 1,494,510 | 1,494,510 | 15,200 | 1,046,325 | 1,061,525 | 2,556,035 |
| SUMMARY | | | | | | | | | | | |
| Subtotal SCS | | | | | | 1,455,110 | 1,455,110 | | 970,740 | 970,740 | 2,425,850 |
| Subtotal FS | | | | | | 39,400 | 39,400 | 15,200 | 75,585 | 90,785 | 130,185 |
| TOTAL PROJECT | | | | | | 1,494,510 | 1,494,510 | 15,200 | 1,046,325 | 1,061,525 | 2,556,035 |

1/ Price Base: 1971.
2/ Includes $1,500 from the going Cooperative Forest Management Program.

Date: April 1972

TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT
(at time of Work Plan Preparation)

Buffalo River Watershed, Virginia

| Measures | Unit | Applied to Date | Total Cost 1/ (Dollars) |
|---|---|---|---|
| LAND TREATMENT | | | |
| Soil Conservation Service | | | |
| Crop Residue Management | acres | 500 | 2,000 |
| Ponds | number | 10 | 4,000 |
| Grassed Waterways or Outlets | acres | 5 | 500 |
| Hedgerow Planting | feet | 1,800 | 270 |
| Pasture & Hayland Management | acres | 5,000 | 50,000 |
| Pasture & Hayland Planting | acres | 100 | 6,000 |
| Channel Improvement | feet | 100,000 | 200,550 |
| Streambank Stabilization | feet | 102,000 | 30,600 |
| Wildlife Habitat Management | acres | 90 | 6,750 |
| Conservation Cropping System | acres | 1,500 | 6,000 |
| Brush Control | acres | 900 | 4,500 |
| Contour Farming | acres | 300 | 1,200 |
| Critical Area Planting | acres | 7 | 1,750 |
| Field Border Planting | feet | 200 | 30 |
| Minimum Tillage | acres | 200 | 200 |
| Drainage-Main or Lateral | feet | 12,000 | 3,600 |
| Drain | feet | 6,000 | 2,700 |
| Spring Development | number | 3 | 450 |
| Drainage-Field Ditch | feet | 6,000 | 1,800 |
| Subtotal SCS | | | 322,900 |
| Forest Service | | | |
| National Forest Land | | | |
| Tree Planting | acres | 15 | 600 |
| Hydrol. Cultural Operations | acres | 279 | 3,320 |
| Private Forest Land | | | |
| Tree Planting | acres | 100 | 1,500 |
| Hydrol. Cultural Operations | acres | 3,000 | 18,000 |
| Subtotal FS | | | 23,420 |
| TOTAL | xxx | xxx | 346,320 |

1/ Price Base: 1971.

Date: April 1972

TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION
Buffalo River Watershed, Virginia
(Dollars) 1/

| Item | Installation Cost P.L. 566 Funds | | | | Installation Cost - Other Funds | | | | | Total Installation Cost |
|---|---|---|---|---|---|---|---|---|---|---|
| | Construction | Engineering | Relocation Payments | Total P.L. 566 | Construction | Engineering | Land 3/ Rights | Relocation Payments | Total Other | |
| Floodwater Retard. Structures: | | | | | | | | | | |
| No. 2 | 293,600 | 17,970 | 290 | 311,860 | | | 34,400 | 210 | 34,610 | 346,470 |
| No. 3 | 146,800 | 9,000 | - | 155,800 | | | 40,400 | | 40,400 | 196,200 |
| Multiple Purpose Structure No. 1B | 570,215 | 25,950 | 7,738 | 603,903 | 171,285 | 7,790 | 259,636 | 5,626 | 444,337 | 1,048,240 |
| Raw Water Intake System | | | | | 10,000 | 3,000 | | | 13,000 | 13,000 |
| Multiple Purpose Structure No. 4 | 116,040 | 7,110 | 752 | 123,902 | 98,860 | 6,050 | 127,350 | 548 | 232,808 | 356,710 |
| Raw Water Intake System | | | | | 9,000 | 530 | | | 9,530 | 9,530 |
| Subtotal | 1,126,655 | 60,030 | 8,780 | 1,195,465 | 289,145 | 17,370 | 461,786 | 6,384 | 774,685 | 1,970,150 |
| Project Administration | xxx | xxx | xxx | 144,845 | xxx | xxx | xxx | xxx | 34,455 | 179,300 |
| | | 2/ | 5/ | | | | 4/ | 5/ | | |
| GRAND TOTAL | 1,126,655 | 60,030 | 8,780 | 1,340,310 | 289,145 | 17,370 | 461,786 | 6,384 | 809,140 | 2,149,450 |

1/ Price base: 1971.
2/ Engineering contract costs to be borne $33,050 by P.L. 566 funds and $17,370 by Other funds.
3/ Includes $7,000 for survey, legal fees and other costs.
4/ Includes $96,000 for raising roads and relocating about 0.85 miles of power and telephone lines.
5/ Relocation payments for displacements prior to July 1, 1972, will be shared as provided in PL 91-646 and in paragraph numbered 2 of the agreement.

Date: April 1972

TABLE 2A - COST ALLOCATION AND COST SHARING SUMMARY
Buffalo River Watershed, Virginia
(Dollars) 1/

| Item | COST ALLOCATION | | | COST SHARING | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Purpose | | | P.L. 566 | | | Other | | |
| | Flood Prev. | Municipal Water S. | Total | Flood Prev. | Municipal Water S. 2/ | Total | Flood Prev. | Municipal Water S. | Total |
| Floodwater Retard. Struc. No. 2 & 3 | 542,670 | | 542,670 | 467,660 | | 467,660 | 75,010 | | 75,010 |
| Multiple Purpose Struc. No. 1B | 806,097 | 242,143 | 1,048,240 | 586,028 | 17,875 | 603,903 | 220,069 | 224,268 | 444,337 |
| Raw Water Intake | | 13,000 | 13,000 | | | | | 13,000 | 13,000 |
| Multiple Purpose Struc. No. 4 | 192,623 | 164,087 | 356,710 | 123,557 | 345 | 123,902 | 69,066 | 163,742 | 232,808 |
| Raw Water Intake | | 9,530 | 9,530 | | | | | 9,530 | 9,530 |
| GRAND TOTAL | 1,541,390 | 428,760 | 1,970,150 | 1,177,245 | 18,220 | 1,195,465 | 364,145 | 410,540 | 774,685 |

1/ Price Base: 1971.
2/ Public Law 83-566 share of municipal water supply cost is for that portion of relocation payments (Public Law 91-646) allocated to water supply.

Date: April 1972

TABLE 3 - STRUCTURAL DATA
STRUCTURES WITH PLANNED STORAGE CAPACITY
Buffalo River Watershed, Virginia

| ITEM | Unit | Structure Number 1-B | 2 | 3 | 4 | TOTAL |
|---|---|---|---|---|---|---|
| Class of Structure | | c: | c: | c: | c: | xxx |
| Drainage Area | Sq. Mi. | 24.07: | 6.80: | 4.99: | 8.12: | 43.98 |
| Curve No. (1-day) (AMC II) | | 67: | 61: | 62: | 66: | xxx |
| $T_c$ | Hrs. | 4.6: | 2.3: | 2.4: | 2.5: | xxx |
| Elevation Top of Dam | Ft. | 799.7: | 759.7: | 712.5: | 655.5: | xxx |
| Elevation Crest Emergency Spillway | Ft. | 789.6: | 750.7: | 702.2: | 646.3: | xxx |
| Elevation Crest Principal Spillway | Ft. | 764.0: | 726.0: | 686.1: | 636.4: | xxx |
| Maximum Height of Dam | Ft. | 85.2: | 69.4: | 55.7: | 55.0: | xxx |
| Volume of Fill | Cu. Yds. | 712,900: | 252,700: | 64,900: | 99,600: | 1,130,100 |
| Total Capacity | Ac. Ft. | 8,657: | 1,751: | 1,429: | 4,461: | 16,298 |
| Sediment Submerged | Ac. Ft. | 1,227: | 447: | 374: | 407: | 2,455 |
| Sediment Aerated | Ac. Ft. | 82: | 30: | 25: | 27: | 164 |
| Beneficial Use (Water Supply) | Ac. Ft. | 2,000: | - : | - : | 2,049: | 4,049 |
| Retarding | Ac. Ft. | 5,348: | 1,274: | 1,030: | 1,978: | 9,630 |
| Surface Area | | | | | | |
| Sediment pool | Acres | 93: | 36: | 41: | 75: | 245 |
| Beneficial use pool (Water Supply) | Acres | 161: | - : | - : | 175: | 336 |
| Retarding pool | Acres | 276: | 78: | 91: | 233: | 678 |
| Principal Spillway | | | | | | |
| Rainfall Volume (areal) (1 day) | In. | 8.59: | 8.90: | 8.90: | 8.90: | xxx |
| Rainfall Volume (areal) (10 day) | In. | 15.74: | 16.00: | 16.00: | 16.00: | xxx |
| Runoff Volume (10 day) | In. | 7.65: | 6.49: | 6.71: | 7.63: | xxx |
| Capacity of Principal Spill.(Max.) | cfs | 714: | 201: | 123: | 264: | xxx |
| Frequency operation-Emer. Spillway | % chance | 1: | 1: | 1: | 1: | xxx |
| Size of Conduit | Dim. | 60 in. | 36 in. | 30 in.: | 42 in.: | xxx |
| Emergency Spillway | | | | | | |
| Rainfall Volume (ESH) (areal) | In. | 11.16: | 12.00: | 12.00: | 12.00: | xxx |
| Runoff Volume (ESH) | In. | 6.86: | 6.72: | 6.86: | 7.46: | xxx |
| Type | | Veg.: | Veg.: | Veg.: | Veg.: | xxx |
| Bottom Width | Ft. | 550: | 300: | 150: | 250: | xxx |
| Velocity of flow ($V_e$) | Ft./Sec. | 8.6: | 8.5: | 8.6: | 7.6: | xxx |
| Slope of exit channel | Ft./Ft. | 0.0255: | 0.0255: | 0.0255: | 0.0275: | xxx |
| Maximum water surface elevation | Ft. | 793.0: | 754.0: | 705.7: | 649.0: | xxx |
| Freeboard | | | | | | |
| Rainfall Volume (FH) (areal) | In. | 25.95: | 27.90: | 27.90: | 27.90: | xxx |
| Runoff Volume (FH) | In. | 20.86: | 21.46: | 21.68: | 22.55: | xxx |
| Maximum water surface elevation | Ft. | 799.7: | 759.7: | 712.5: | 655.5: | xxx |
| Capacity Equivalents | | | | | | |
| Sediment Volume | In. | 1.02: | 1.31: | 1.50: | 1.00: | xxx |
| Retarding Volume | In. | 4.16: | 3.51: | 3.87: | 4.57: | xxx |

Date: April 1972

USDA-SCS-HYATTSVILLE, MD. 1972

TABLE 4 - ANNUAL COST

Buffalo River Watershed, Virginia

(Dollars) 1/

| Evaluation Unit | Amortization of 2/ Installation Cost | Operation and Maintenance Cost | Total |
|---|---|---|---|
| All Structural Measures | 106,467 | 5,500 | 111,967 |
| Project Administration | 9,689 | xxx | 9,689 |
| GRAND TOTAL | 116,156 | 5,500 | 121,656 |

1/ Price Base: Installation 1971, O & M 1970 Adjusted Normalized Prices.

2/ 100 years @ 5-3/8 percent interest.

Date: April 1972

TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Buffalo River Watershed, Virginia

(Dollars) 1/

| Item | Estimated Average Annual Damage: Without Project | With Project: | Damage Reduction Benefit |
|---|---|---|---|
| Floodwater | | | |
| Crops and Pasture | 8,370 | 250 | 8,120 |
| Other Agricultural | 2,405 | 505 | 1,900 |
| Roads and Bridges | 4,820 | 490 | 4,330 |
| Major Improvements | 4,230 | 705 | 3,525 |
| Subtotal | 19,825 | 1,950 | 17,875 |
| Sediment | | | |
| Overbank Deposition | 2,120 | 335 | 1,785 |
| Downstream Channel | 78,440 | 38,350 | 40,090 |
| Subtotal | 80,560 | 38,685 | 41,875 |
| Erosion | | | |
| Flood Plain Scour | 1,480 | 450 | 1,030 |
| Subtotal | 1,480 | 450 | 1,030 |
| Indirect | 19,175 | 8,180 | 10,995 |
| Total | 121,040 | 49,265 | 71,775 |

1/ Price Base: 1970 Adjusted Normalized Prices.

Date: April 1972

TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Buffalo River Watershed, Virginia

(Dollars)

| Evaluation Unit | AVERAGE ANNUAL BENEFITS 1/ | | | | | | | Average Annual Cost 3/ | Benefit Cost Ratio |
|---|---|---|---|---|---|---|---|---|---|
| | Damage Reduction | More Intensive Land Use: Agr. | More Intensive Land Use: Urban | Municipal Water Supply | Incidental Recreation | Local Secondary | Total | | |
| All Structural Measures | 58,785 | 19,250 | 25,400 | 71,165 | 40,170 | 9,185 | 223,955 | 111,967 | 2.0:1.0 |
| Project Administration | xxx | | xxx | xxx | xxx | xxx | xxx | 9,689 | xxx |
| GRAND TOTAL | 58,785 2/ | 19,250 | 25,400 | 71,165 | 40,170 | 9,185 | 223,955 | 121,656 | 1.8:1.0 |

1/ Price Base: 1970 Adjusted Normalized Prices.

2/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of $12,990 annually.

3/ From Table 4.

Date: April 1972

## INVESTIGATIONS AND ANALYSES

### Economic Investigations

Floodwater Damages and Annual Benefits to Damage Reduction - Flooding of agricultural land is a major type of damage in this watershed. Substantial damages also occur to flood plain improvements which include a municipal water supply treatment facility, highways, bridges, homes, businesses, and various agricultural improvements. Damage schedules were obtained through personal interviews with about 50 percent of the flood plain landowners. This information was developed to reflect physical losses experienced from floods in recent years. Damage information was collected for all major improvements expected to be affected by the 100-year frequency storm. Use was also made of special studies made in Amherst County following Hurricane Camille in August 1969.

Damage schedules were tabulated and evaluated based on the Interim Price Standards for Planning and Evaluating Water and Land Resources, April 1966. Damages to improvements were adjusted to account for changes in future values making use of OBERS per capita income projections described in SCS Regional Technical Service Center TSC-Technical Note - Watersheds - UD-26, November 1970.

Agricultural damages were also based on the landowner interviews. These interviews covered land use, crop distribution, average yields and experienced damage to cropland at various seasons of the year. This information was analyzed and used with other data to develop values and damage rates for crops and pasture by months and depth of flooding.

More Intensive Land Use Benefits - These benefits were based on those acres of the protected flood plain where it was indicated that high intensity of agricultural use and management would be practiced. The present intensity of use, degree of flood protection provided, managerial skill, soil capabilities, resources available and other factors were considered in determining those areas on which high intensity agricultural practices might be followed.

The installation of works of improvement making these land use changes possible will not result in an increased acreage of surplus crops. Production of crops in this watershed is directly related to the on-farm feeding needs and the needs of the livestock, dairy and poultry operations. Implementing of this plan will divert cultivated crops from some of the steeper, more erodible, uplands to more favorable bottomlands.

Non-Agricultural Changed Land Use Benefits - These benefits are described in the Economics Guide as "enhancement-type benefits" to non-agricultural areas as a result of the project. The annual equivalent of the increased value of land was the method used to develop the monetary value of these benefits.

Studies made during work plan development indicated that at least 150 acres of flood plain land would be needed for nonagricultural development by 1980, and another 100 to 125 acres by 1985 to meet the anticipated demand. This need is based on population projections made by the Bureau of Population and Economic Research of the University of Virginia and information furnished by local planning groups.

Indirect damages to crops and pasture were determined to be at least 10 percent of the direct damages. The indirect damages to flood plain improvements were estimated to be at least 20 percent of the direct damages to these improvements.

Benefits from Restoration of Former Productivity - During field investigations, farmers were asked what changes had been made in the use of their flood plain lands as a result of past flooding. They were also asked what changes they would make if flooding were reduced. Analysis of these responses and projected future land use trends and land capability for the area provided the basis for estimating the benefits from restoration of their lands to former use. Other factors considered in this analysis were size and location of the affected farms, land capability, existence of markets, managerial skill of the operator and reduction in frequency of flooding. Benefits to restoration of former productivity were calculated by summarizing land use acreages, yields and net income and changes in cropping patterns. The loss of production was considered as crop and pasture damage and its restoration a benefit in table 5. The change in cropping pattern involves land now mostly in crops and native pasture which would normally be used for higher income crops or improved pasture with the flood hazard reduced. These benefits were discounted sufficiently to allow for any associated costs connected with this change and for lag in accrual.

Erosion and Sedimentation Damages

Erosion and sediment damages were estimated from information obtained by field investigations made jointly by a geologist and an economist. The value of sediment and erosion damages is related to the value of potential productive capacities in the affected areas as compared to present production on damaged land.

Downstream sediment damages were based on the estimated sediment yield to the James River and its Hampton Roads Estuary from the Buffalo River Watershed project. The value of each acre-foot of sediment delivered to the James River was related to dredging costs obtained from the U. S. Army, Corps of Engineers. A cost of $1.46 per cubic

yard was used. This is not intended to imply that all of these sediments will be removed downstream by dredging but is merely an assumed minimal value of the damage caused by sediment based on dredging costs.

Downstream benefits from reduced sedimentation were based on the net reduction of sediment yield to the James River by comparing sediment production with and without project conditions.

Flood plain overbank sedimentation and scour damage reduction benefits within the Buffalo River project area were based on a reduction of these damages by planned conservation land treatment and structural measures. The damages were adjusted for expected recovery of production allowing for a lag in recovery.

Local Secondary Benefits stemming from the project are considered to be 10 percent of the direct primary benefits. These include such items as increased use of transportation, processing and marketing of the goods and services that produce the primary project benefits. Local secondary benefits induced by the project are considered to be 10 percent of the increased costs primary producers will incur in connection with increased production.

Fish and Wildlife

The Bureau of Sport Fisheries and Wildlife prepared a report on their investigations in this watershed. The Service Biologist participated in the inter-agency field examination of this watershed and made recommendations for the fish and wildlife report. He also provided material to describe the fish and wildlife features in the watershed. The steep, upper elevations of the North and South Forks of Buffalo River and Thrashers Creek are stocked at irregular intervals with about 6,000 brook and rainbow trout by the Virginia Commission of Game and Inland Fisheries. These areas are largely in the George Washington National Forest well upstream from the impoundment sites proposed in this plan. An estimated 2,000 fisherman days annually is provided by these streams in the years they are stocked. Nearly all of the private land in the watershed is posted, with public access for hunting and fishing not permitted. This project is expected to enhance the fish and wildlife habitat, recreation and environmental potential of the area. Amherst County will own the impoundment areas of all four dams and plans to develop limited recreational use at each location. Incidental benefits for the type of development planned were evaluated for each structure proposed in this work plan. User days were estimated based on use currently being experienced at structures in Virginia which have been developed in a manner similar to that planned by Amherst County for this watershed.

Economic Evaluation methods and procedures used in developing this watershed work plan conform to those set forth in the Economics Guide for Watershed Planning and Flood Prevention and the Watershed Protection Handbook.

Land Rights costs for the works of improvement were determined by the land rights committee of the sponsors. These costs are based on the anticipated cost of purchases and other considerations the sponsors expect to incur in securing the lands for installation of this project.

Land Treatment Measures

Land treatment measures were planned in accordance with the capabilities of the land to reduce erosion, sedimentation and improve hydrologic conditions. Field investigations were made to determine the land treatment needs and locate areas needing special attention. The sediment producing problem areas on non-Federal land were considered to be of such proportion as to be adequately cared for by accelerated installation of land treatment measures including the tree planting and other recommended forestry measures.

A request will be made by the U. S. Forest Service for a supplemental appropriation to meet the land treatment needs in the George Washington National Forest.

Additional fire protection measures were not found to be needed, as the present protection is within the established watershed standards. It is not anticipated that there will be any increase in fire occurrence during the construction as a result of any installation activities on the watershed.

Engineering Investigations and Analyses

The vertical control network for the watershed consists of a system of temporary bench marks at road intersections, stream crossings, structure sites, and other strategic locations. These bench marks were connected to the mean sea level datum through closed circuits of differential levels. Open traverses, U.S.G.S. Topographic Quad. Sheets (7-1/2 minute series), and aerial photographs were used for the horizontal control needed.

A total of 71 valley cross sections, including 7 highway crossings, were run for use in making hydraulic computations. Stream profiles were plotted using elevations from the cross sections, and distances scaled from the aerial photographs (1" = 660').

All probable structure sites were first located on aerial photographs and available topographic maps, and were then examined in the field. Two floodwater retarding structures and two multiple-purpose structures were selected as the system which would most efficiently control and utilize the water resources of the area.

All structures were placed in the class "c" category in accordance with criteria described in Engineering Memorandum SCS-27 (Rev.). These structure classifications were reviewed and approved by the State Conservation Engineer.

A reservoir topographic map (1" = 200'), with four foot contour intervals, was developed for each of the four structure sites and used in making stage-storage computations. A detailed topographic map of the construction area (1" = 50') was also developed for each site. These maps, with two to four foot contour intervals, were used in centerline locations and emergency spillway layouts. All existing structures including buildings, roads, and public utilities were located and plotted on the above maps. Photographic reductions of the reservoir topographic maps (1" = 660') were made for use in obtaining necessary land rights.

Topographic maps of the flood plain (1" = 100'), with a contour interval of two feet, were developed for ten locations having potential urban type damages. Sites 1 through 6 extend along the main stem from Structure No. 1B to a short distance below Thrashers Creek. Site 7 is along Thrashers Creek between Structure No. 2 and Highway No. 610. Sites 8 and 9 are located adjacent to and downstream from Highway No. 778. Site 10 is almost adjacent to and downstream from Highway No. 29. These maps were used to delineate the 100-year flood lines for present and future conditions, and to evaluate the benefits resulting from the combination of dams and emergency channel work.

The design of structures is based on Soil Conservation Service criteria as set forth in Engineering Memorandum SCS-27 (Rev.), Technical Release No. 2, Section 4, Chapter 21 of the National Engineering Handbook, U. S. Weather Bureau Technical Papers 40 and 49, SCS Standard Drawing No. ES-1020, and other recognized sources of engineering material. All routings were made by electronic computer.

Routings for structure No. 1B, with the drainage area adjusted from 24.07 square miles to 10.00 square miles, were made to help determine design features of this structure. These routings were based on the actual stage-storage curve for the site, point rainfall amounts, adjusted time of concentration, and adjusted amounts of sediment and water supply storage. The principal spillway hydrograph was first routed to set the crest elevation of the emergency spillway. Several trial widths were used in making Emergency Spillway and Freeboard Hydrograph Routings. The Emergency Spillway Routing was used to select a width associated with the allowable velocity for the site. The Freeboard Routing was used to establish limiting values for outflow volume per foot of bottom width, exit channel velocity, and duration of flow through the emergency spillway. A favorable comparison between these values was obtained by using a 550 foot width for the 24.07

square mile drainage area, and a 250 foot width for the 10.00 square mile drainage area. Results of the comparison are included in the engineering design folder for structure No. 1B.

A detailed geologic investigation, which will include core drilling, will be made during construction. A final determination will be made at that time concerning any additional design features which may be necessary to obtain a stable emergency spillway.

Engineering cost estimates were based on unit costs from contracts for similar projects in Virginia. The Engineering News Record Construction Cost Index was used in updating these figures to the 1971 price base. Earth fill volume computations and emergency spillway excavation quantities were made by electronic computer. Concrete and steel quantities were computed by accepted engineering procedures. A preliminary emergency spillway layout was made for each structure and used as a guide in proportioning the structure. A comparative cost study, using variable bottom widths for the emergency spillway, was made to obtain the most economical structure proportions consistent with sound engineering practice standards.

Consulting Engineers' Report

Amherst County, a sponsor in the Buffalo River Watershed project, retained consulting engineers to ascertain the desirability of participating in the development of multipurpose reservoirs as a source of water supply for the county. Projections for the year 2000 show that 8.0 mgd are required to serve both population and industrial needs. Minimum downstream release was determined to be 0.038 cubic feet per second per square mile which is equal to the critical discharge (ten year drought-seven day duration.)

The report clearly indicates that multipurpose development of two sites is the most economical alternative. It also states that: the quantity of water, based on yield studies, is adequate to meet the demand; the quality of the water is suitable for domestic water supply; the sites are satisfactory from the standpoint of location, elevation, and water holding ability.

Hydraulic and Hydrologic Analyses

The Buffalo River watershed was delineated on U.S.G.S. Quadrangles of the 15 minute series. This formed a map on which the watershed was divided into subareas and routing reaches. Eight reaches were selected on the main stem and four on tributaries. Each of these was used as an evaluation reach but one on a tributary where a dam was dropped. All drainage areas were measures from this map with a planimeter.

Valley cross sections were selected and surveyed to represent the hydraulic characteristics of the natural valley and stream channel. Detail surveys of bridges and roadways were made in order to calculate their effect on the backwater curves that would be developed during project planning. The surveyed cross sections were located on aerial photographs, flood plain strip maps, and on the U.S.G.S. Quadrangles covering the area. The flood plain strip maps, which were prepared from stereoscopic studies of contact prints, were

used to measure channel and flood plain lengths. The U.S.G.S. Quadrangles were used to measure the drainage area above each surveyed valley cross section. These valley cross sections were initially used to run selected water surface profiles on the electronic computer.

Rating curves and stage-area inundated curves were prepared for each representative cross section from the computer output tabulations.

Valley flood routings for evaluation were made with the electronic computer as outlined in SCS Technical Release No. 20.

The rainfall for the 24-hour evaluation series was taken from U. S. Weather Bureau T.P. 40. It was converted to the annual series and plotted on probability paper to get a straight line relationship by percent chance of occurrence. The 3.85, 5.81, and 8.69 inch rainfalls were selected from this plotting for use in the evaluation flood routings.

The runoff curve numbers for use in valley flood routing and for structure design were prepared from the soil cover complex data for the watershed. The soil cover complex was prepared from data provided by the District Conservationist and Soil Scientist of the SCS and by personnel of the Virginia Division of Forestry. This data was prepared separately for the area above each possible dam site and the remaining area below the sites. The procedure for preparation of the soil cover complex was taken from Chapters 7, 8, and 9 of the SCS National Engineering Handbook, Section 4.

The time of concentration was calculated for each subarea of the watershed by use of ES-1015 and stream hydraulics. The without project time of concentration was revised for the with project routing and design of dams 1B and 4 to reflect the length of the water supply pool.

A tabulation of subarea numbers, drainage areas, times of concentration, runoff curve numbers, rainfall, and routing reach lengths was made for use in completing computer forms for valley flood routing. Discharge and end area for various elevations were calculated for an average cross section for each routing reach to be used by the computer to calculate routing coefficients.

The routed flood peaks, tabulated from the computer output, were plotted on probability paper for each alternate routing. The plotting position for the three routed storms was determined by an analysis of five stream gages in the area. These positions on the probability scale were used at the ends of all reaches in the watershed. The annual series peak discharges were read from the line of best fit in each case and tabulated on a sheet for conversion

to the partial duration series. Selected storm peaks, using the partial duration column for frequency, were placed on a spread sheet. This sheet was prepared to summarize area flooded by frequency. Peak discharges for each frequency were calculated at each cross section within each reach by proration from the values at the ends of the reach. Area inundated for each value at each cross section was tabulated. Total area inundated for each reach was added for each frequency. These values were used to plot a stage-area inundated curve for each reach, related to one cross section for economic evaluation.

A discharge-frequency curve was prepared for each reach for economic evaluation. Peak discharges on the above mentioned conversion sheets were prorated to the same section used to summarize area inundated in each reach. These values were then used to plot the discharge-frequency curves on logarithmic paper. A line was prepared and plotted for without project, with land treatment, and with project conditions. The procedure followed is outlined in Chapter 18 of the SCS National Engineering Handbook, Section 4.

The design hydrology for the dams was prepared for the engineering phase of the work plan development. The drainage areas, runoff curve numbers, and times of concentration were taken from the data prepared for valley flood routings. The 100-year one-day and ten-day rainfall amounts for the principal spillway routings were prepared from U. S. Weather Bureau Technical Papers 40 and 49, respectively. The method of hydrograph development for determination of minimum flood storage is described in SCS National Engineering Handbook, Section 4, Chapter 21. Emergency spillway and freeboard storm design rainfall amounts were taken from SCS drawings ES-1020 for the class "c" criteria as described in SCS Engineering Memorandum 27. The method of hydrograph development for the emergency spillway and freeboard storms is also outlined in the SCS National Engineering Handbook, Section 4, Chapter 21. All design storms were prepared for routing on the electronic computer.

Water Budget Analysis

Conclusions from Study: A computer analysis was made of dams 1B and 4 using 42 years of record. A demand rate of 5 M.G.D. and 3 M.G.D. was used for dams 1B and 4, respectively. These amounts were arrived at by plotting several mass curves before setting up the computer analysis. It appears that the demand on site 1B was slightly high and that on site 4 could be higher. Therefore, they were adjusted to 4.7 M.G.D. for 1B and 3.5 for dam 4, giving a total usable demand for municipal use of 8.2 M.G.D. This allows for evaporation, rainfall on lake surface, seepage losses, and downstream release.

The driest period in the 42 year record was the early 1930's. Stream flow built up quickly after this drought however. Several other droughts occurred, but the one selected for this study was the 1960's. This period was used because stream flow has continued to diminish through this period. This type of period is hard on reservoir storage due to losses along with comparatively low inflow.

Generally speaking the demand could be much higher than the 8.2 M.G.D., but if another period like that from 1963 to 1966 were to develop then this would be about the upper limit of use.

There was no time during the period of record that the reservoirs took over a year to refill. In general where there was any drawdown of the pools they refilled within a 6 or 7 month period.

## Alternatives Considered

Seven dam sites were selected on the Buffalo River watershed in the preliminary stage. Two additional tributaries were studied for possible sites. Preliminary valley flood routings eliminated three of the seven dam sites originally selected for study. The two additional tributaries had numerous easement problems which made the selection of dam sites look impractical. The remaining four dam sites that looked promising were located on the main stem of Buffalo River, Thrashers Creek, Stonehouse Creek, and Mill Creek. The main stem site was moved twice in an attempt to reduce the cost of moving a portion of U. S. Highway 60. Several alternate valley flood routings were made with the four remaining dams to help select possible construction units. These routings were made on the electronic computer trying dam 1B only, dams 2 and 3 only, and dam 4 only.

Channel work was considered in areas designated as having potential for urban development. Due to several uncontrolled tributaries, the size and cost of the channel required for complete 100-year protection would be prohibitive.

## Sedimentation Investigations

A field examination of the flood plain was conducted to determine the type and extent of sediment and related damages. Erosion rates were calculated by use of the Musgrave formula and data from the field examination. Highways were investigated to determine where active bank erosion was occurring.

All procedures and formulas used are similar to those in the Soil Conservation Service Technical Release 17.

Geologic Investigations

Geologic investigations consisted of a study of the available literature and aerial photographs of the area and a thorough examination of the conditions in the field. A preliminary examination of the dam sites was conducted and depths of overburden were determined where possible with a hand auger, portable seismograph, and other hand tools.

The structures are located at the edge of the Piedmont and Blue Ridge Physiographic Provinces. The bedrock consists of igneous and metamorphic rocks mainly gneisses, granites, schists and phyllites. The depths to bedrock under the foundations should be shallow, 10 feet or less, with possibly some deeper former channels covered with alluvium, in most cases bedrock outcrops are present in stream bottoms. The rock surfaces are expected to be uneven due to differential weathering characteristic of these rock types. The material to be excavated from the emergency spillways will range from GM to some CH (according to the Unified Soil Classification System) with SM predominating. Seismic velocities indicate that much of the rock encountered will be weathered and rippable but because of depths of cuts rock excavation is anticipated. A certain amount of seepage should be expected near the contact of hard bedrock. Detailed site investigations are planned for all sites to determine what types of foundation drainage and treatment are necessary.

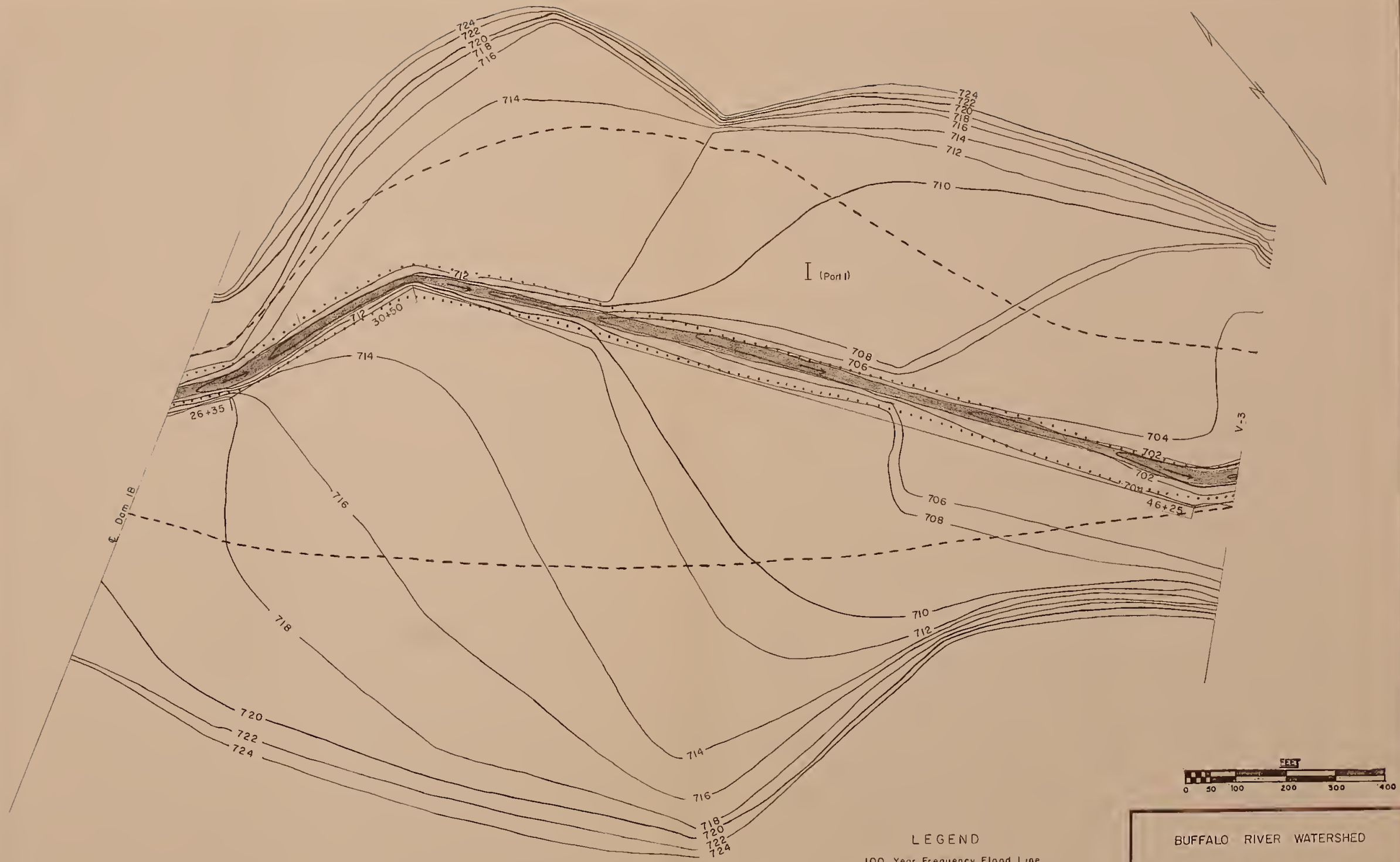
Site #1B - Dam will be 85.2 feet high and 1,270 feet long. Abutment slopes range from 10 to 60 percent. The underlying bedrock is gneiss and phyllite of the Marshall gneiss. Emergency spillways are planned in both abutments. Seismic velocities indicate the rock is rippable but because of the depth of cut, rock excavation has been included. Borrow material from the spillway cuts, abutment areas and pool areas will range from GP to CH with the majority being SM to ML. The flood plain close to the stream is coarse well rounded gravel. No rock was found in the stream at the centerline but outcrops are present about 200 feet upstream. Site 1B is a multipurpose site so a deeper cut off is planned in the left abutment to alleviate a possible leakage problem. The narrow abutment is to be removed and replaced with impermeable fill material.

Site #2 - Dam will be 69.4 feet high and 830 feet long. Abutment slopes range from 0 to 75 percent. The underlying rock is the Marshall gneiss which is a jumble of igneous and metamorphic rocks mainly gneisses and schists. The emergency spillway will be located in the left abutment. Most of the excavation will be rippable but some rock is expected. Rock is shallow in the stream and outcrops are present beside the stream and upstream about 150 feet. Borrow is available from the spillway, left abutment and pool area.

Site #3 - Dam will be 55.7 feet high and 420 feet long. Abutment slopes range from 15 to 50 percent. The underlying bedrock is a green to black gneiss of the Marshall gneiss. The stream bed is solid rock from about 200 feet upstream to about 500 feet downstream. The emergency spillway will be located in the left abutment. Most of the spillway will be rippable but some rock excavation is expected. The borrow will all come from the emergency spillway cut.

Site #4 - Dam will be 55 feet high and 865 feet long. Abutment slopes range from 0 to 60 percent. The underlying bedrock is a granite gneiss of the Marshall gneiss. There is rock in the right stream bank and outcrops upstream about 100 feet. The emergency spillway will be located in the right abutment. Seismic velocities indicate most of the excavation will be rippable but some rock is expected. The borrow will come from the emergency spillway cut and the pool area. This site is to be multipurpose so the detailed investigation can better ascertain the foundation drainage and treatment necessary. A deep cut off trench has been included to prevent any leakage through the right abutment. This cut off will be excavated to relatively impermeable material.

Stream Channel Improvement - No stream channel improvement is planned in this watershed. The bank material is generally SM to ML and in most of the downstream area below dams there is bedrock control in the channel.




LEGEND

100 Year Frequency Flood Line

Without Project – – – – – –

With Project . . . . . .

BUFFALO RIVER WATERSHED

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

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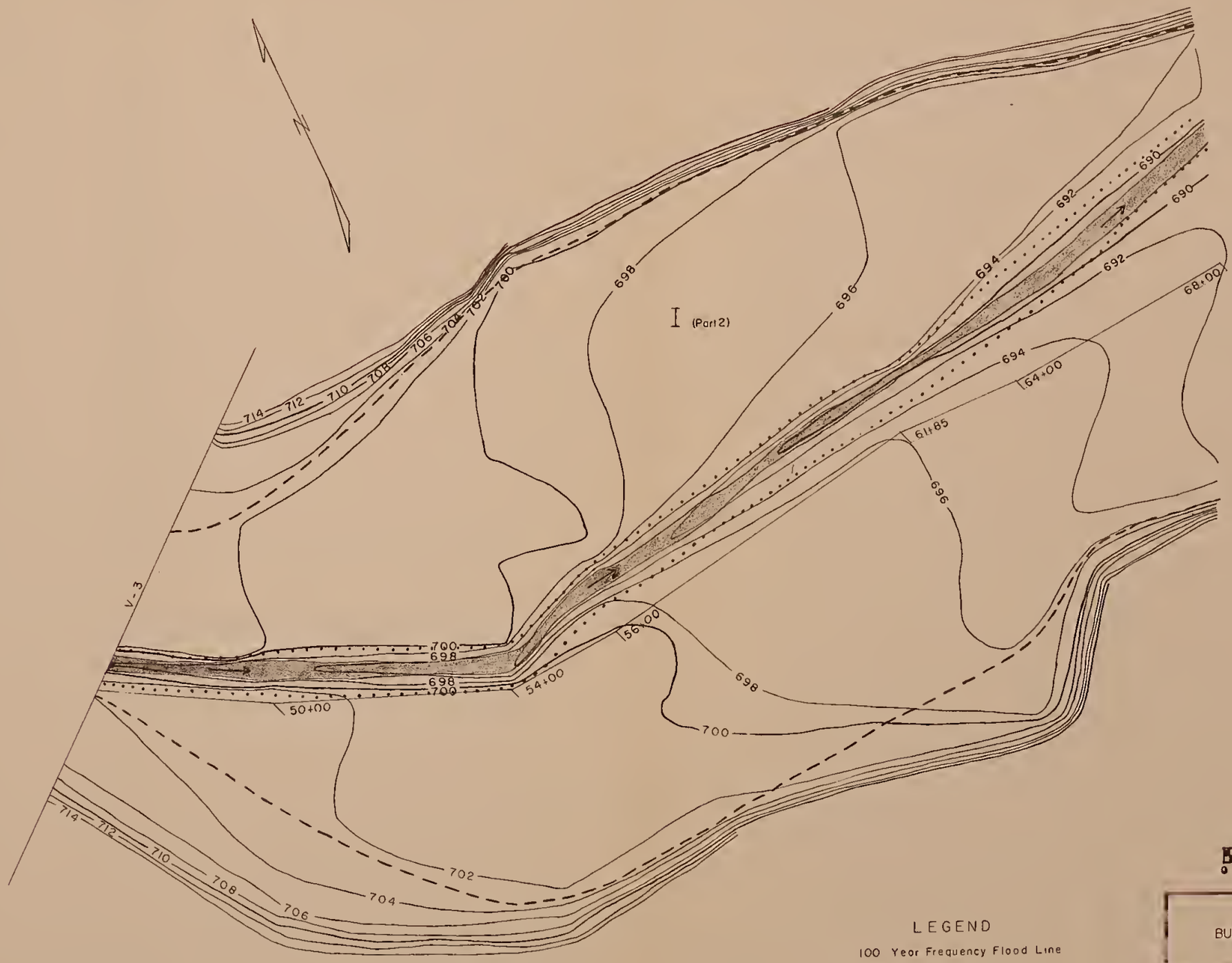


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100 Year Frequency Flood Line

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BUFFALO RIVER WATERSHED

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BUFFALO RIVER WATERSHED

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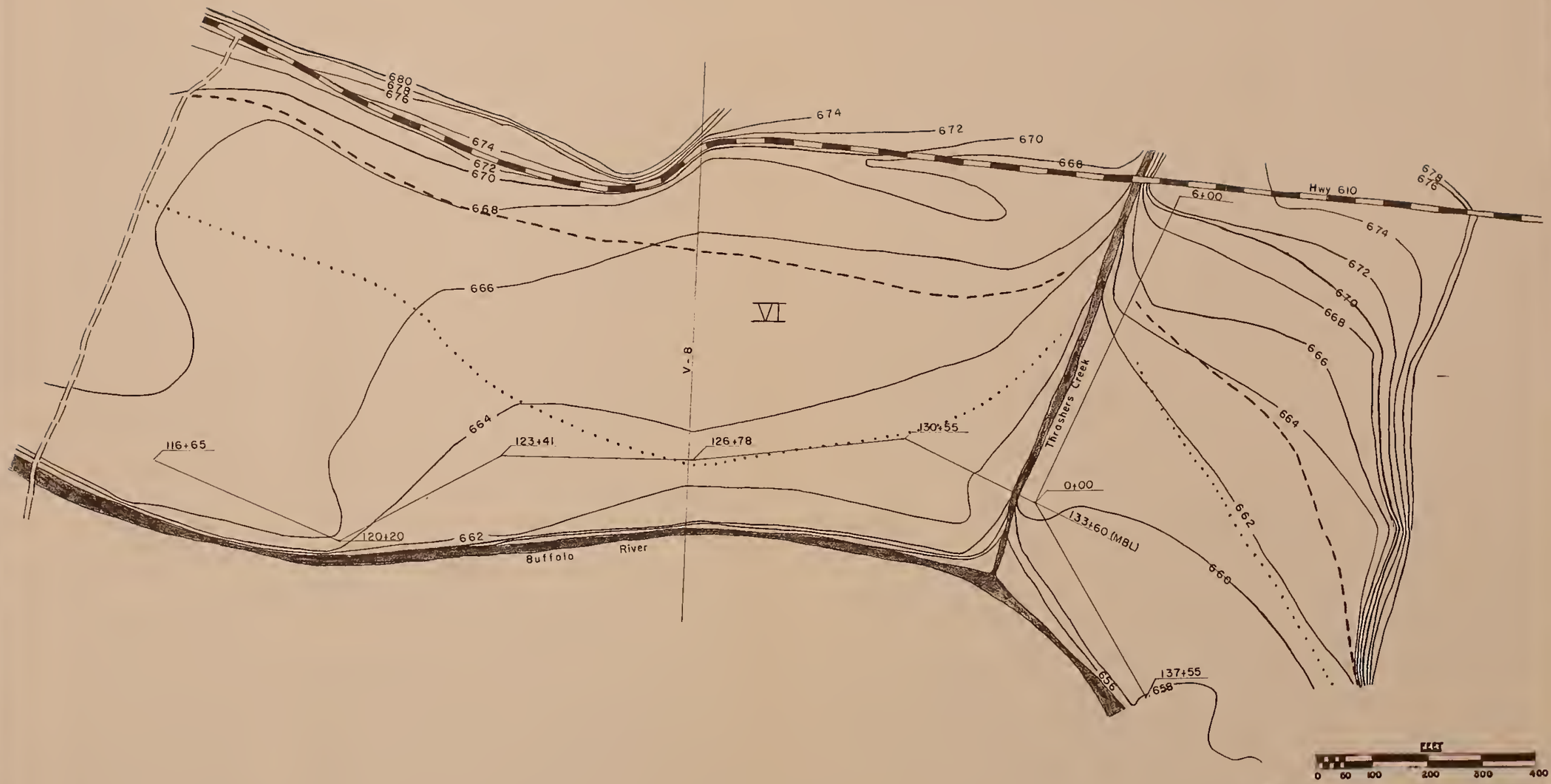


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BUFFALO RIVER WATERSHED

U. S. DEPARTMENT OF AGRICULTURE
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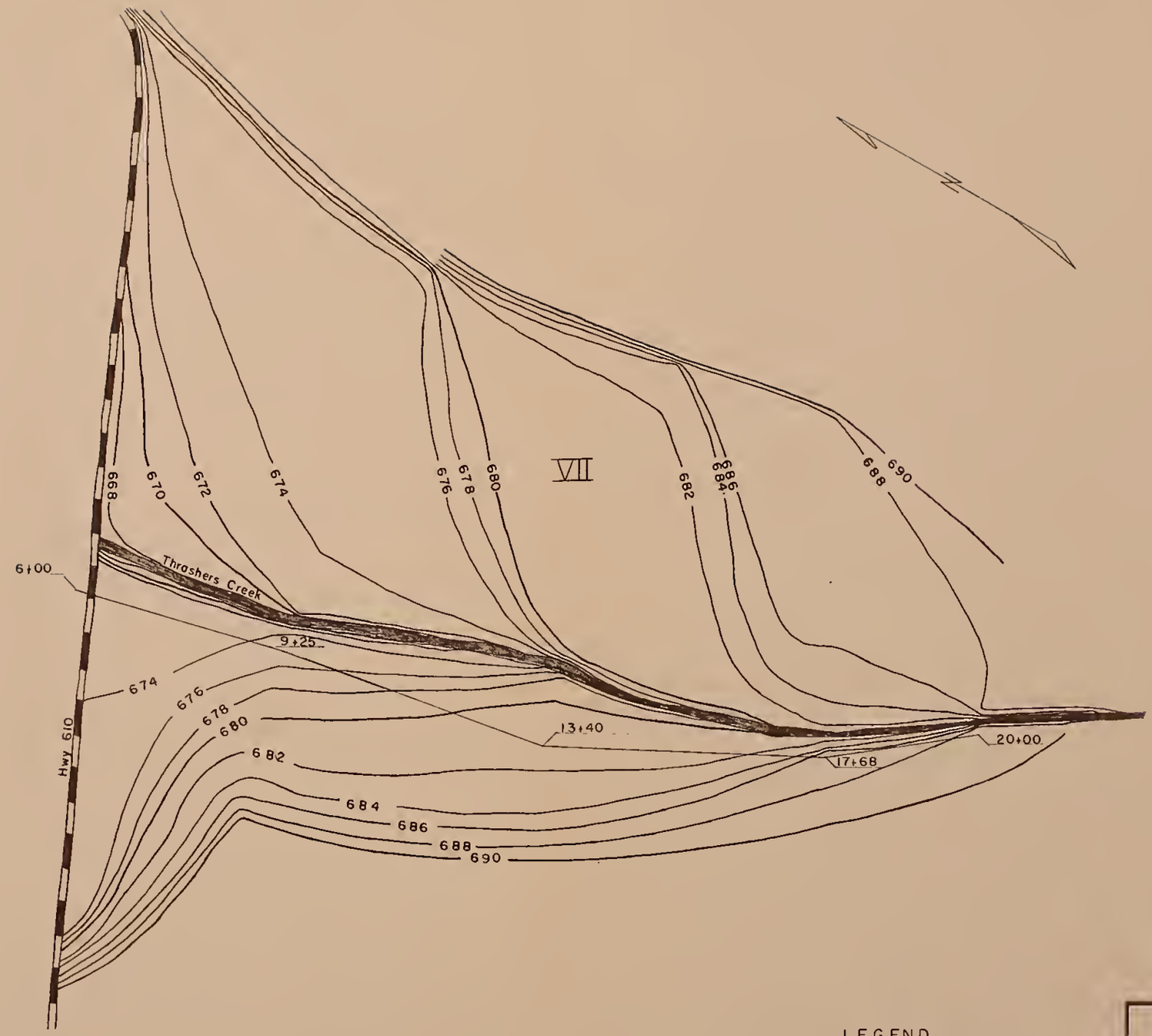


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BUFFALO RIVER WATERSHED

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SOIL CONSERVATION SERVICE

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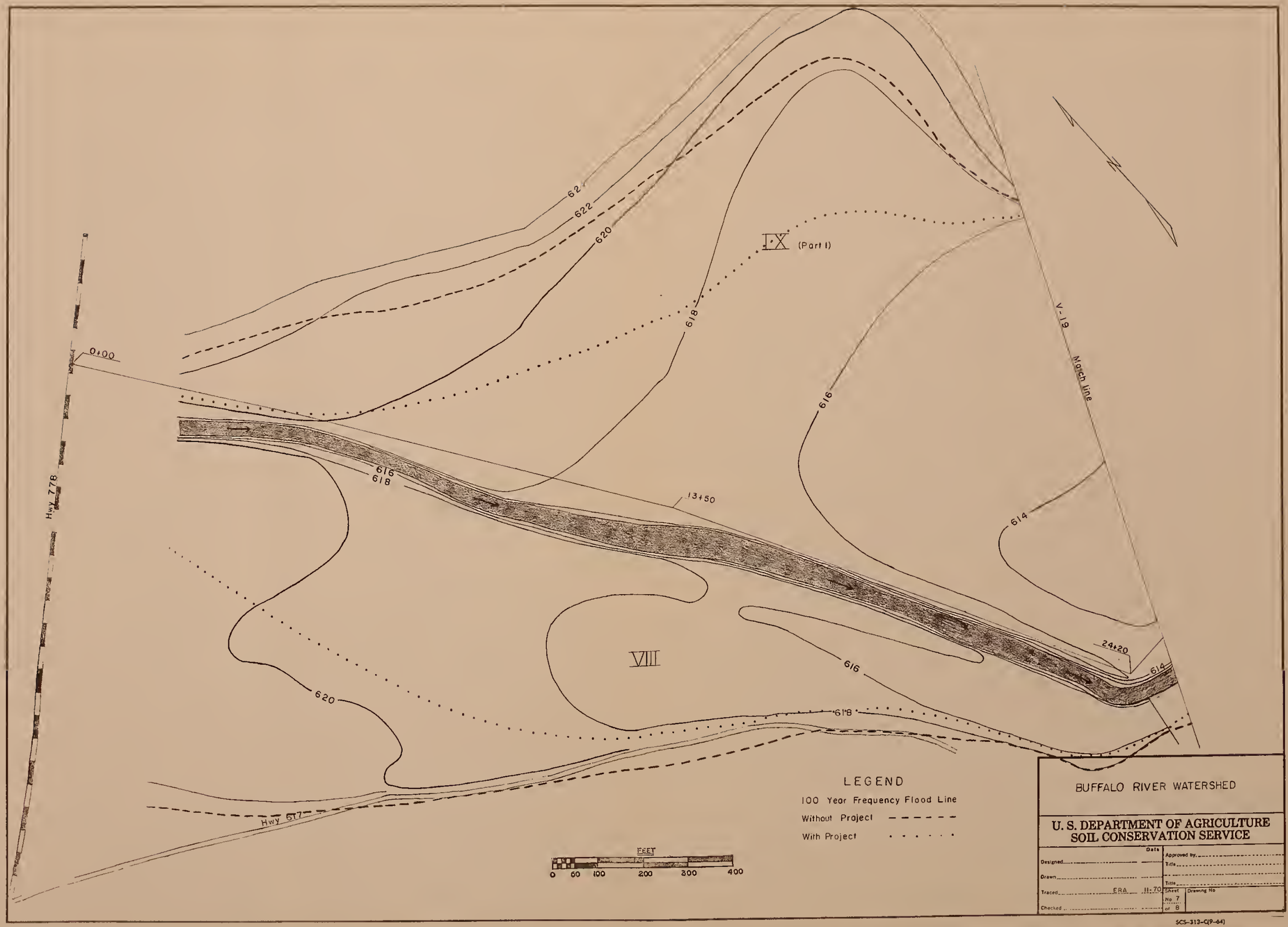


BUFFALO RIVER WATERSHED

**U. S. DEPARTMENT OF AGRICULTURE**
**SOIL CONSERVATION SERVICE**

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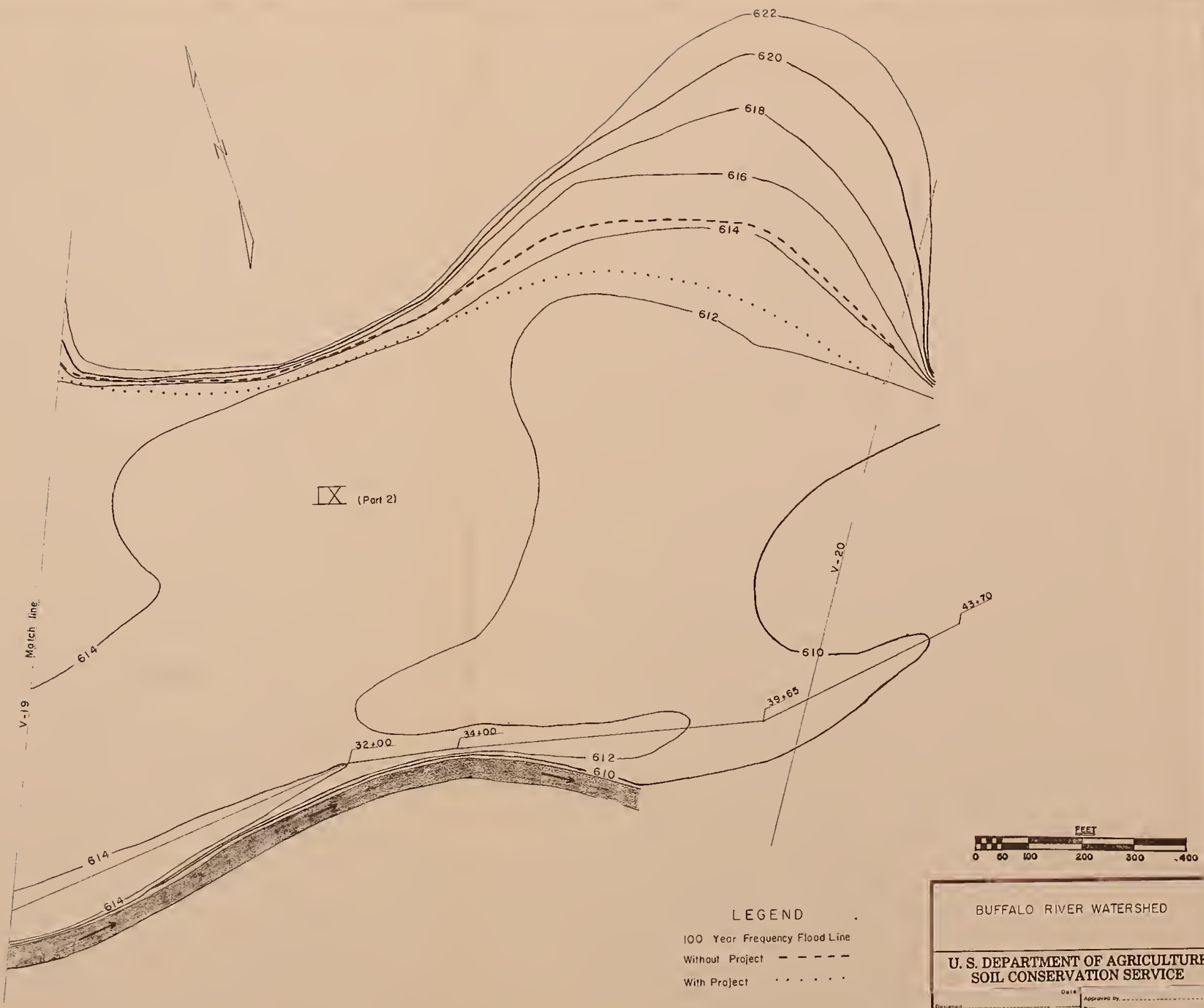


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100 Year Frequency Flood Line

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BUFFALO RIVER WATERSHED

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

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USDA-SCS-HYATTSVILLE, MD 1971 SCS-312-C(9-64)

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

# PROJECT MAP
# BUFFALO RIVER WATERSHED

## AMHERST COUNTY, VIRGINIA

Scale 1:126720

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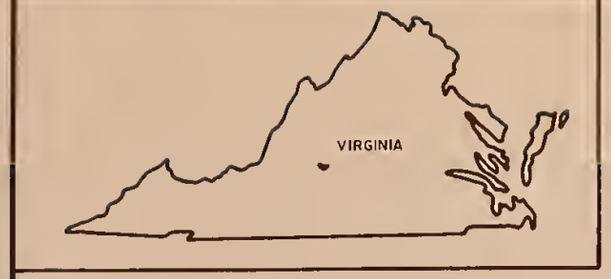


79° 15' 79° 10' 79° 05' 79° 00'

37° 45'

37° 40'

37° 35'


N

## LEGEND

- Road
- Railroad
- Power-transmission line
- Stream
- National forest boundary
- City boundary
- Watershed boundary

### PROJECT MEASURES

- Drainage area controlled by structure
- Area benefited
- D. A. — Drainage area in acres
- A|B — Damage reach
- Floodwater retarding structure
- Multiple-purpose structure M-Municipal
- (4) — Structure number

June 1971

USDA-SCS HYATTSVILLE, MD 1971